AD NUMBER

ADB096490

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; SEP 1985. Other requests shall be referred to Air Force Electronic Systems Division, ESD-TCF-3, Hanscom AFB, MA 01731-5000. This document contains export-controlled technical data.

AUTHORITY

afgl ltr 25 apr 1988

(2)

ESD-TR-85-111 MTR-9575

PRIME ITEM DEVELOPMENT SPECIFICATION FOR DIGITAL TROPOSCATTER MODEM

By

SHEPARD WENGLIN

SEPTEMBER 1985

Prepared for

DEPUTY COMMANDER FOR TACTICAL SYSTEMS
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
Hanscom Air Force Base, Massachusetts

Project No. 492T
Prepared by
THE MITRE CORPORATION
Bedford, Massachusetts
Contract No. F19628-84-C-0001

REVIEW AND APPROVAL

This technical report has been reviewed and is approved for publication.

Guy M Harn

GUY M. HARN, GS-13
Project Engineer/Scientist

FOR THE COMMANDER

Anida G Wisnietsky

ANIDA G. WISHNIETSKY, Major, USAF
DEB Program Manager
Overseas C^3 Systems Directorate

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

AD-B096 490

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS None
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Distribution limited to U.S. Government agencies and their contractors; Administrative/Operational Use; September 1985. (over)
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) MTR-9575 ESD-TR-85-111	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION The MITRE Corporation 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State and ZIP Code) Burlington Road Bedford, MA 01730	7b. ADDRESS (City, State and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Deputy Commander for (over) 8b. OFFICE SYMBOL (If applicable) TCF-3	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F19628-84-C-0001
8c. ADDRESS (City, State and ZIP Code) Electronic Systems Division Air Force Systems Command Hanscom AFB, MA 01731-5000	10. SOURCE OF FUNDING NOS. PROGRAM ELEMENT NO. / PROJECT NO. 492T / TASK NO. / WORK UNIT NO.
11. TITLE (Include Security Classification) Prime Item Development Specification (over)	
12. PERSONAL AUTHOR(S) Shepard Wenglin	
13a. TYPE OF REPORT Final 13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Yr., Mo., Day) 1985 September 15. PAGE COUNT 68
16. SUPPLEMENTARY NOTATION	
17. COSATI CODES FIELD / GROUP / SUB. GR.	18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) DEB Digital European Backbone Digital Troposcatter Modem Diversity Combiner Specification TDM (over)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The Prime Item Development Specification for the Digital Troposcatter Modem was written for the Air Force procurement of the modem. These modems are intended principally for Defense Communication System (DCS), Digital European Backbone (DEB) application on troposcatter links. The modem includes all modulation functions, diversity combiner functions, power supplies, fault sensing and alarm circuits, internal time division multiplex (TDM) functions, performance monitoring and display functions necessary to convert a dual or quad diversity troposcatter radio to digital operation. It will carry mission bit stream rates of 1.544 Mb/s, 3.232 Mb/s, 6.464 Mb/s or 9.696 Mb/s plus a service channel of 192 Kb/s.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ OTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Claudette G. Hanley	22b. TELEPHONE NUMBER (Include Area Code) (617) 271-7994 22c. OFFICE SYMBOL M/S D230

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

3. (continued) Other requests for this document shall be referred to HQ ESD/TCF-3, Hanscom AFB, MA 01731-5000.

8a. (continued) Tactical Systems

11. (continued) for Digital Troposcatter Modem

18. (continued) Time Division Multiplex

ACKNOWLEDGEMENTS

The author would like to thank Ugo Garganese and Richard Lima who contributed the sections on Reliability/Maintainability and Materials, Processes and Parts, respectively. Also, thanks are due to Jack Cohen for his editorial and substantive contributions. Special thanks go to Doris Nardone for her patient, efficient and cheerful typing support.

This report has been prepared by the MITRE Corporation under Project 492T, Contract F19628-84-C-0001. The contract is sponsored by the Electronic Systems Division, Air Force Systems Command, Hanscom Air Force Base, Massachusetts.

PREFACE

The Air Force has been tasked to be lead service in the production of Digital Tropo Modems to be used in the digital upgrade of certain tropo links in the European Defense Communication System (DCS).

The upgrade of these links (and in at least one case, the establishment of a new link) is part of the Digital European Backbone (DEB) program. Recent advances in the design of adaptive digital modems now make it possible to achieve high data rates (in this case approximately 10 Mb/s) with good reliability over the fading dispersive troposcatter channel. The AN/TRC-170 with data rates up to 4 Mb/s, now in production, is one example of the use of an adaptive digital modem for tropo application. Another example is the MD-918/GRC, with data rates up to 12 Mb/s, which has completed its development phase.

An earlier version of this specification has been used as part of the RFP package for competitive bidding for the production contract for the Digital Troposcatter Modem. The present version (April 1985) reflects the culmination of all contractual negotiations.

TABLE OF CONTENTS

Section | Page

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION 1

SCOPE

1.1 GENERAL

This specification establishes the performance, design, development and test requirements for the Digital Troposcatter Modem AN/XXX, hereinafter to be referred to as the modem. In addition, this specification provides overall physical characteristics including, but not limited to: size, weight, spectral constraints, power requirements. These modems are intended principally for Defense Communication Systems, Digital European Backbone application on troposcatter links.

SECTION 2

APPLICABLE DOCUMENTS

2.1 GOVERNMENT DOCUMENTS

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be the superseding requirement.

SPECIFICATIONS

Military

MIL-E-4158E(2) 12 July 1977	General Requirements for Ground Electronic Equipment
MIL-B-5087B Amendment 2 31 Aug 1970	Bonding, Electrical, and Lightning Protection for Aerospace Systems
MIL-P-11268K 31 Aug 1978	Parts, Materials, and Processes Used in Electronic Communications Equipment
MIL-F-14072B 19 April 1976	Finishes for Ground Electronic Equipment
MIL-S-19500F Notice 4 12 April 1982	Semiconductor Device, General Specification for
MIL-C-21097C Supp 1D Amendment 5 31 Dec 1980	Connector, Electrical, Printed Wiring Board, General Purpose General Specification for
MIL-M-38510E Supp 1C 30 August 1983	Microcircuits General Specification for

MIL-I-46058C
8 Nov 1982
Insulating Compound, Electrical (for Amendment 6 Coating Printed Circuit Assemblies)

MIL-H-46855B
Amendment 1
5 April 1982
Human Engineering Requirement for Military Systems, Equipment and Facilities

Equipment Specifications

TT-C1-6201-109
12 November 1980
SCN01 27 Jan 1983
Performance and Interface Specification for TSEC/KG-81 Trunk Encryption Device

CCC-74047
Rev B
8 July 1983
Change 1
19 Aug 1983
Specification for Multiplexer/Demultiplexer, AN/FCC-98

CCC-74048A
28 July 1983
Change 1
28 Nov 1983
Change 2
10 Feb 1984
Specification for Multiplexer/Demultiplexer, AN/FCC-99

CCC-77048
22 Jan 1979
Specification for Low Speed Time Division Multiplexer/Demultiplexer (AN/FCC-100)

STANDARDS

Federal

FED-STD-595A
Notice 4
1 Aug 1973
Colors

Military

MIL-STD-109B
4 April 1969
Quality Assurance Terms and Definitions

MIL-STD-130F 21 May 1982	Identification Marking of U.S. Military Property
MIL-STD-143B 12 Nov 1969	Order of Precedence for the Selection of Specifications and Standards
MIL-STD-188-114 24 March 1976	Electrical Characteristics of Digital Interface Circuits
MIL-STD-454H Notice 1 1 Sept 1982	Standard General Requirements for Electronic Equipment
MIL-STD-461B 1 April 1980	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462 Int. Notice 4 1 April 1980	Electromagnetic Interference Characteristics, Measurement of.
MIL-STD-471A Int. Notice 2 27 March 1973	Maintainability Demonstration
MIL-STD-721C 12 June 1981	Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors and Safety
MIL-STD-781C Notice 1 20 March 1981	Reliability Tests: Exponential Distribution
MIL-STD-810C Notice 1 7 April 1981	Environmental Test Methods
MIL-STD-883B Notice 5 15 Jan 1982	Test Methods and Procedures for Microelectronics
MIL-STD-965 15 April 1977 Notice 1 22 Dec 1978 Notice 2 16 Feb 1981	Parts Control Program

MIL-STD-1188A 5 Jan 1978	Commercial Packaging of Supplies and Equipment
MIL-STD-1472C 2 May 1981	Human Engineering Design Criteria for Military Systems, Equipment and Facilities

OTHER PUBLICATIONS

Manuals

TM11-5820-727-12 September 1969	Department of the Army Technical Manual, Operator and Organizational Maintenance Manual Radio Terminal Set AN/TRC-132A
31R5-2FRC-102 -103 -104	Technical Manual, Operational/ Maintenance, Radio Terminal Set AN/FRC-96, Up-converter
31R5-4-195-2	Technical Manual, Operational/ Maintenance, Radio Terminal Set AN/FRC-96, Down-converter

Handbooks

AFSC Design Handbook 1-4 5 July 1979	Electromagnetic Compatibility
AFSC Design Handbook 4-2 10 June 1976	Electronic Systems Test and Evaluation
MIL-HDBK-472 24 May 1966	Maintainability Predictions

Regulations

AFR 66-1 21 April 1983	Maintenance Management
AFR 66-14 15 Nov 1978	Equipment Maintenance Policy, Objectives and Responsibilities

Miscellaneous

2.2 NON-GOVERNMENT DOCUMENTS

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, this specification shall be the superseding requirement.

Specification for Computer Controlled Quad Diversity Troposcatter Simulator [Model S236C], December 1984 (RADC Purchase Requisition Number F3300143240010 for Stock Number 6625PS236A).

2.3 AVAILABILITY OF DOCUMENTS

Copies of specifications, standards, drawings, and other publications required in connection with specified procurement functions should be obtained from the Procuring Activity or as directed by the Contracting Officer.

SECTION 3

REQUIREMENTS

3.1 ITEM DEFINITION

The modem shall include all modulation and demodulation functions, diversity combiner functions, power supplies, fault sensing and alarm circuits, internal time division multiplex (TDM) functions, performance monitoring and display functions necessary to convert a dual or quad diversity troposcatter radio to digital operation.

Modulation shall include: the multiplexing of mission and service channel bit streams; modulation of 70 MHz carriers, and filtering to achieve the required spectral constraints.

Demodulation shall include IF amplification, diversity combining, adaptive equalization, detection, demultiplexing of mission and service channel bit streams.

The modem shall be capable of continuous, unattended operation 24 hours a day.

3.1.1 Item Diagrams

See figures 3-1 and 3-2.

3.1.2 Interface Definition

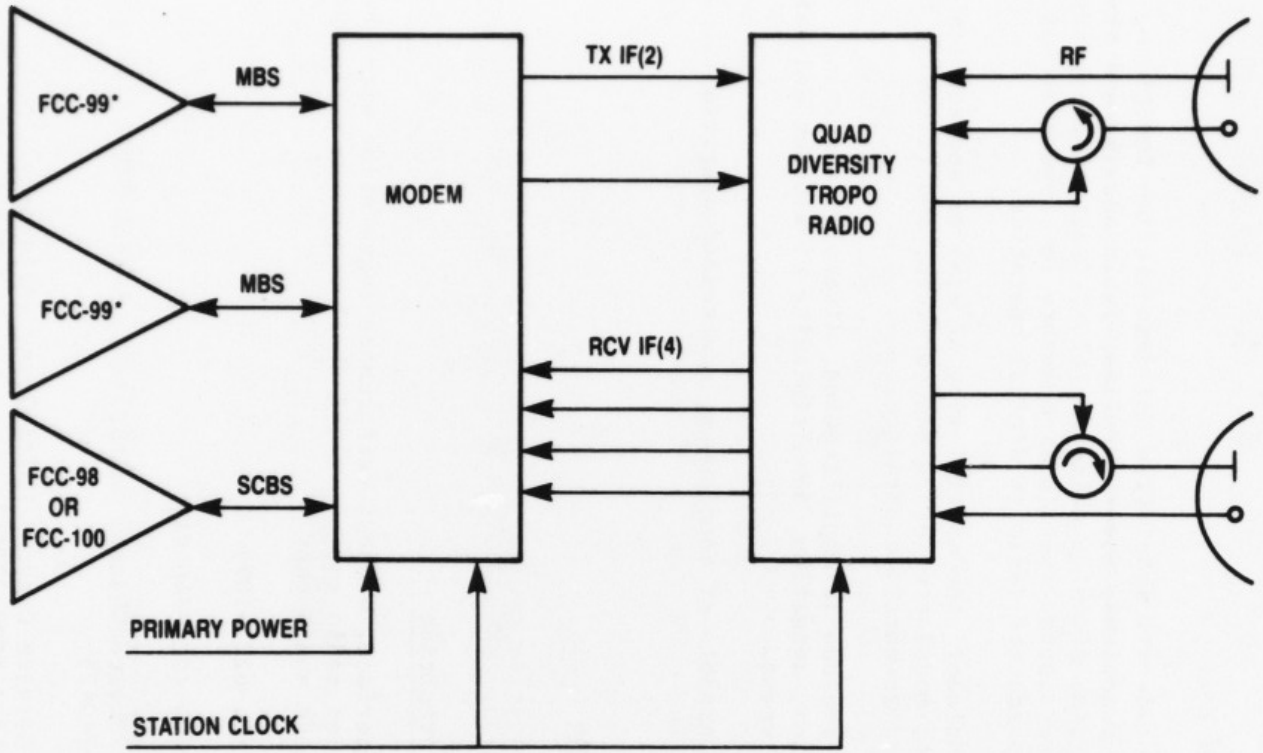
The modem shall interface, without performance degradation with the following digital and radio equipment and shall not cause performance degradations to these equipments.

a. KG-81 (TT-C1-6201-109)

b. AN/FCC-99(V) (CCC-74048A)

c. 192 Kb/s Service Channel Multiplexer, AN/FCC-98(V) (1X)(CCC-74047)

d. 192 Kb/s Service Channel Multiplexer (Alternate), AN/FCC-100(V) (CCC-77048)



*OR KG-81 OR FCC-98

Figure 3-1. TROPO TERMINAL CONFIGURATION

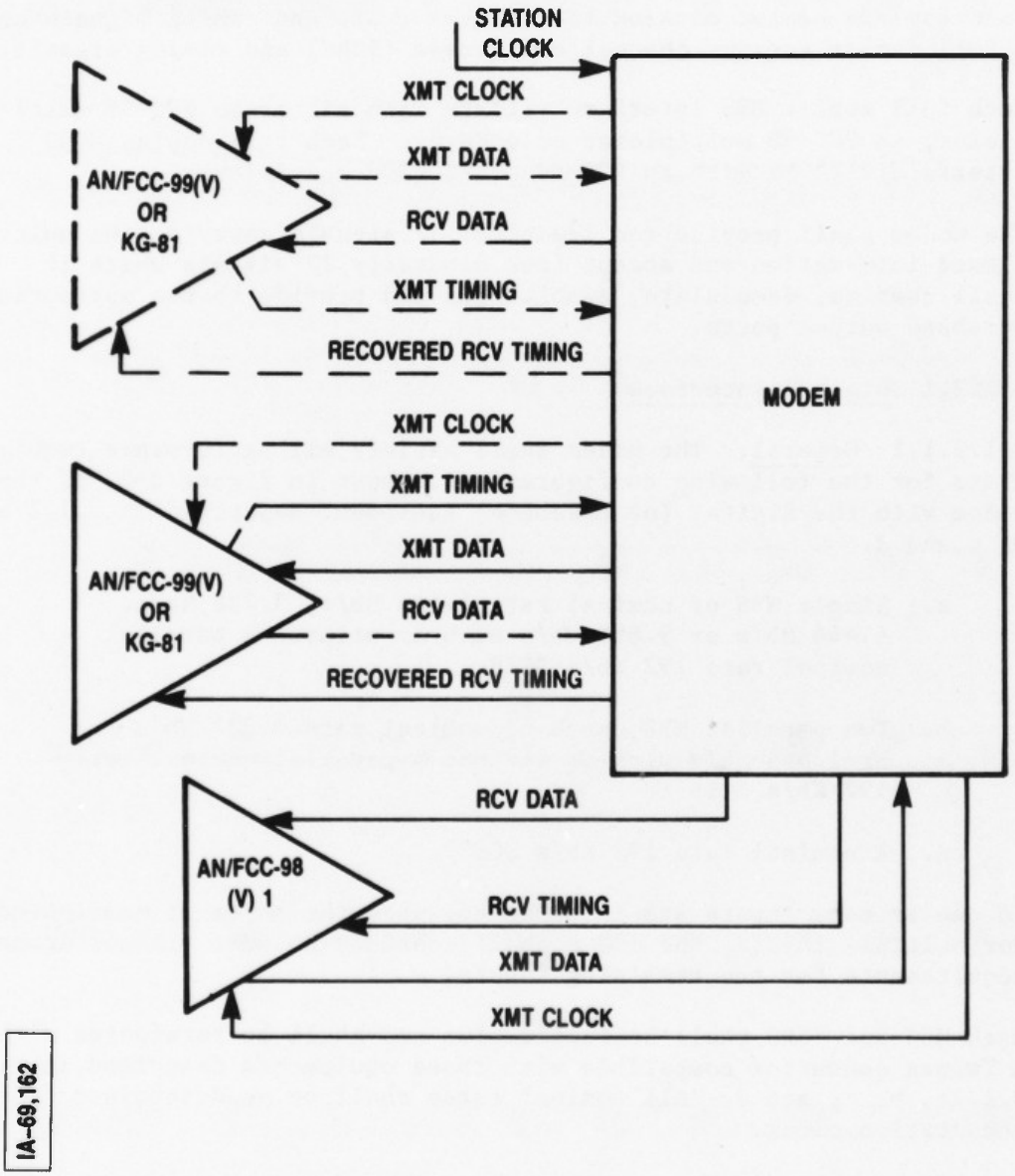


Figure 3-2. DATA INPUT/OUTPUT CONFIGURATION

e. AN/TRC-132A Radio Terminal Set

f. AN/FRC-96 Radio

As shown in figure 3-1 the modem shall provide a full duplex interface for one or two mission bit streams (MBS) and timing signals and a full duplex service channel bit stream (SCBS) and timing signals.

Each full duplex MBS interface will be with either an FCC-99 multiplexer, an FCC-98 multiplexer or a KG-81. Each full duplex SCBS interface will be with an FCC-98 or FCC-100 multiplexer.

The modem shall provide two identical IF signals carrying the multiplexed information and accept four diversity IF signals which it shall combine, demodulate, demultiplex and provide to the appropriate baseband output ports.

3.1.2.1 Digital Interface

3.1.2.1.1 General. The modem shall satisfy all performance requirements for the following configurations, shown in figure 3-2, of the modem with the digital (or baseband) equipment described in 3.1.2 a, b, c,and d.

a. Single MBS of nominal rate 1.544 Mb/s, 3.232 Mb/s, 6.464 Mb/s or 9.696 Mb/s with or without a parallel nominal rate 192 Kb/s SCBS

b. Two parallel MBS, each of nominal rate 3.232 Mb/s or 1.544 Mb/s with or without a parallel nominal rate 192 Kb/s SCBS

c. A nominal rate 192 Kb/s SCBS

If one or more inputs are interrupted, when the modem is configured for multiple inputs, the modem shall continue to meet all performance requirements for the remaining inputs.

Each MBS and SCBS shall be full duplex and shall be terminated with a Twinax connector compatible with those equipments described in 3.1.2a, b, c, and d. All nominal rates shall be as determined from the station clock.

3.1.2.1.2 Data and Clock Input/Output Signals. For each output data signal (RCV data in figure 3-2) there shall be an associated timing signal (Recovered RCV Timing in figure 3-2).

Each input MBS data signal (XMT data) may be configured to be synchronous with a clock signal (XMT clock) which the modem shall provide and which the modem derives from a station clock, or the input MBS data signal may be configured to be synchronous with the multiplexer clock. In the latter case (transmit data synchronous with the multiplexer clock) a transmit timing signal (XMT timing) will be available as an input to the modem. If the transmit data is synchronous with the transmit clock provided by the modem, no transmit timing signal shall be required as an input to the modem. The modem shall be capable of operating in either mode.

The same relationships of data and clock input/output signals shall hold true for the SCBS with the exception that transmit data will always be synchronous with a transmit clock signal which the modem shall provide.

In all these possible cases the modem shall meet all performance requirements.

3.1.2.1.3 Multiplexer Clock Source and Timing Offset. When the modem is configured to accept a single MBS input data signal, with or without a SCBS, which is synchronous with the multiplexer clock, it shall have the capability to operate with no degradation in performance (under worst-case conditions) and without losing any bits or stuffing any bits for 24 hours, with a constant frequency difference of ± 1 part in 10^9 between the modem clock (derived from the station clock input) and the multiplexer clock.

3.1.2.1.3.1 Two MBS With Timing Offset. When the modem is configured to accept two MBS input data signals, with or without a SCBS, and each MBS is synchronous with different multiplexer clocks which are each different from the modem clock, the modem shall operate with no degradation in performance and without losing any bits or stuffing any bits for 24 hours, when the worst-case constant difference between any pair of the three clocks is no greater than ± 1 part in 10^9.

3.1.2.1.4 Digital Input/Output Signal Characteristics. The modem shall provide and accept serial non-return-to-zero (NRZ) polar square wave (equal positive and negative duration) data and timing signals. The square wave timing signals shall be at the same rate and aligned with the data signals to which they correspond, such that one cycle of the square wave timing signal is equal in duration to a data unit interval (the reciprocal of the bit rate) and the positive to negative transition of the timing signal occurs in the nominal center of the data unit interval.

3.1.2.1.5 Output Voltage Level. For the NRZ data and timing, a positive voltage is a logic one and a negative voltage is a logic zero. The circuit output voltage at the interface when terminated in its characteristic impedance, shall be ±2 volts, ±10 percent.

3.1.2.1.6 Output Rise and Fall Times. The data and clock pulse output rise and fall times Tr and Tf, in figure 3-3, when measured between the 10 percent and 90 percent points shall be greater than 4 nanoseconds and less than 12 nanoseconds.

3.1.2.1.7 Output Data/Timing Relationships. The trailing edge positive-to-negative transition of an output timing signal shall occur within ±4 percent of the center of the nominal unit interval of the output NRZ data signal to which it corresponds as shown in figure 3-4.

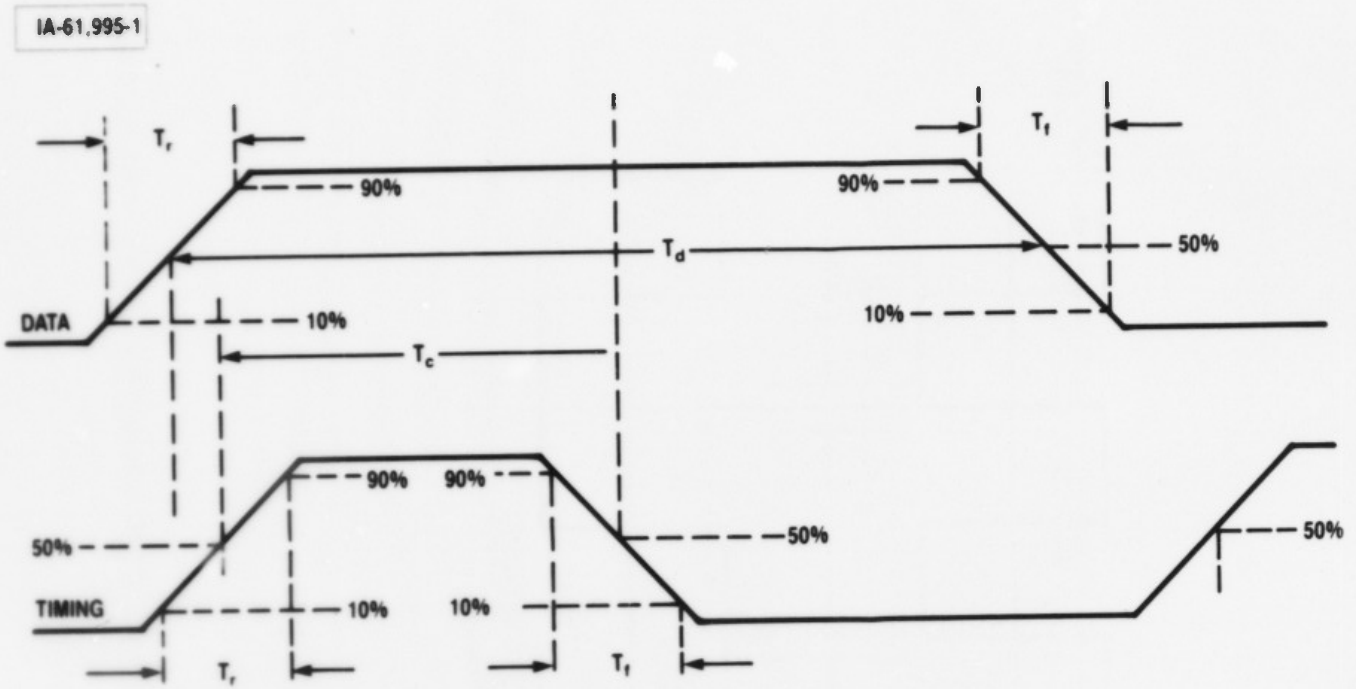
3.1.2.1.8 Output Jitter. The output data and timing signals shall not have more than ±4 percent jitter (peak-to-peak) of the data unit interval. Jitter is defined as the variation of the zero crossings of the signal from whatever cause, including noise.

3.1.2.1.9 Input and Output Impedance. The input cable termination and the output impedance shall be 78 ohms ±10 percent, balanced, for NRZ data and timing inputs. The capacitive shunt shall be less than 15 picofarads to ground.

3.1.2.1.10 Input Voltage Level. At the digital inputs a voltage level from ±0.2 to ±7.0 volts shall be correctly detected and processed without adjustment. Voltage levels up to and including ±14 volts shall not cause damage to the modem.

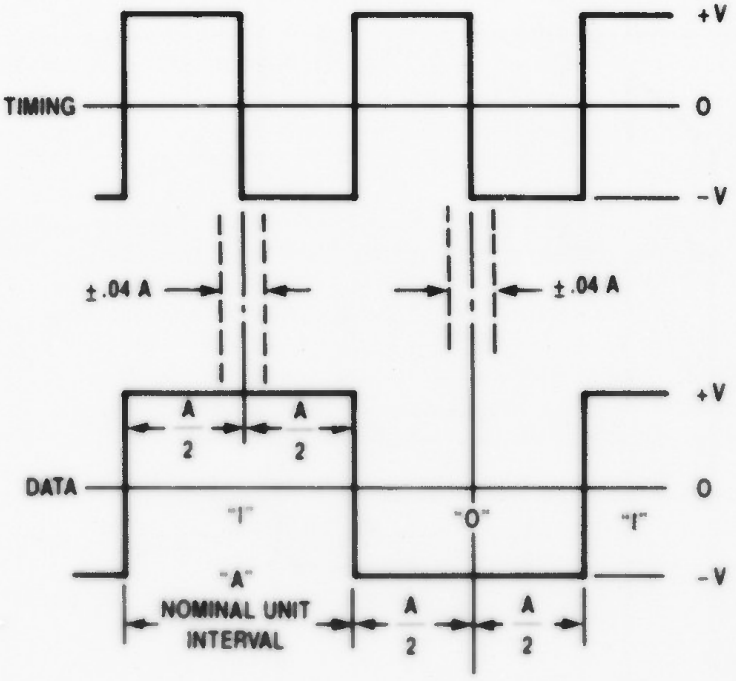
3.1.2.1.11 Input Combined Effects of Jitter. The modem shall satisfy all performance requirements with digital NRZ data and timing inputs each having jitter (in the sense defined in 3.1.2.1.8) equal to as much as 12.5 percent of a data unit interval or a peak timing to peak data excursion of 25 percent of the data unit interval, as indicated in figure 3-5.

3.1.2.1.12 Lockup Protection. The operation of the modem shall be such that when a 25-volt pulse is applied simultaneously to any combination of input/output leads, no logic lockup shall occur that results in service outage or degraded performance requiring manual intervention to restore service. The rise time of the voltage pulse shall be 0.5 volts/nanosecond with a duration of 1 microsecond between the 50 percent amplitude points.



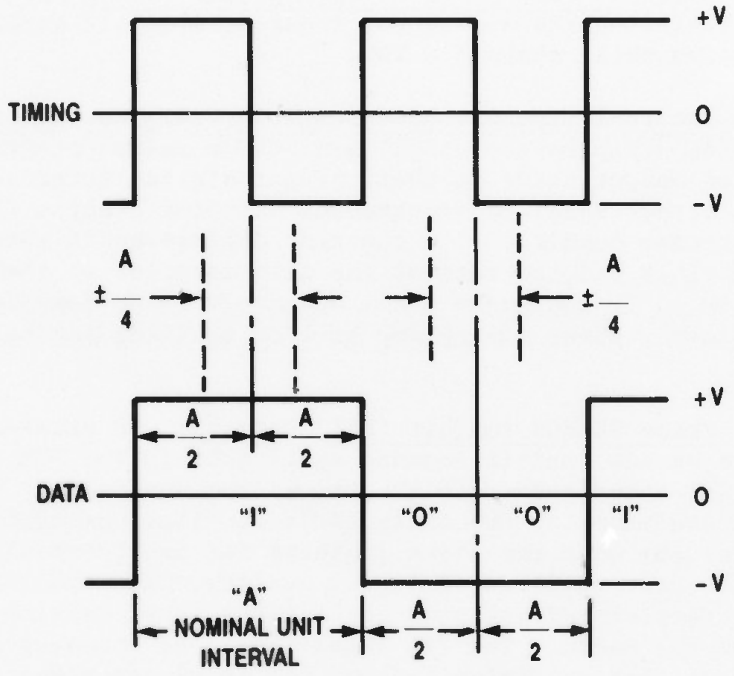
LEGEND:
T_d: NOMINAL DATA UNIT INTERVAL
T_c: NOMINAL TIMING INTERVAL
T_f: FALL TIME
T_r: RISE TIME

Figure 3-3. DATA/TIMING RISE AND FALL TIMES



IA-61.997-1

Figure 3-4 PHASING (OUTPUT DATA & TIMING RELATIONSHIPS — TRAILING EDGE)



IA-61,996-1

Figure 3-5. SAMPLE INTERVAL (INPUT DATA & TIMING RELATIONSHIPS — TRAILING EDGE)

3.1.2.1.13 Interface Protection. Interface protection shall be provided to the extent specified in MIL-STD-188-114, paragraph 5.1.4 Protection, elements (a) through (d), except that in (a) voltage magnitudes of 25 volts are required rather than being a design objective.

3.1.2.1.14 Internal Time Division Multiplexer (TDM). For the purpose of multiplexing the one or two input mission bit streams and the SCBS, the modem shall contain a TDM.

3.1.2.1.15 Internal Time Division Demultiplexing and Timing. The modem shall demultiplex the MBS(s) and SCBS received at its IF interface and output these at their proper digital interface ports. The digital output shall be synchronous with the station clock. For, (under worst-case conditions) a constant difference in rate between the station clock and the rate of the data received at the IF inputs of ± 1 part in 10^{10}, the modem shall operate with no degradation in performance and without losing any bits or stuffing any bits for 9 hours.

3.1.2.1.16 Frame SEARCH Inhibit (FSI) Command. An external multiplexer frame search inhibit command shall inhibit the PCM and TDM multiplexer(s) interfaced with the modem from unnecessary reframe searches when either (a) the modem is in its frame reacquire (loss of BCI) mode, or (b) when the modem inhibits its own internal TDM frame search due to poor received IF signal quality. The command signal shall be a transistor-transistor-logic (TTL) level available at a connector on the modem. The TTL signal shall be normally a logic one (high) when neither condition (a) nor (b) above are present and shall be a logic zero (low) when conditions (a) or (b) are present to inhibit multiplexer frame searches. The TTL command signal shall be capable of controlling up to 16 multiplexers.

3.1.2.2 IF Interface

3.1.2.2.1 Transmit Modem Level and Impedance. The modem shall provide two separate modulated 70 MHz IF outputs at a level which is adjustable from -4 dBm to +16 dBm, with a minimum resolution of 1 dB. The source impedance shall be 50 ohms ± 10 percent, unbalanced, measured over the applicable authorized bandwidth at an IF center frequency of 70 MHz.

3.1.2.2.2 Receive Modem Level and Impedance. The modem shall accept 1, 2, 3, or 4 separate diversity modulated 70 MHz IF inputs from the troposcatter radio. The modem shall meet the performance stated herein with a range of mean IF input signal levels from -10 dBm to -80 dBm inclusive at 50 ohms $\pm 10\%$ source impedance.

3.1.2.2.3 RF Spectrum Occupancy. The modem IF output shall be such that after frequency conversion to RF and amplification, under conditions stated herein, the resulting transmitted signal shall satisfy the following spectral definition:

$$A = [10 \log_{10} B + 0.6 (P-50) -15] \text{ dBc}$$

where: A is the minimum attenuation of the spectral density outside the authorized bandwidth measured as the power falling in a 4 kHz band, below the total mean emitted power;

B is the authorized bandwidth in kHz;

P is the displacement from the center frequency of the emission expressed as a percentage of B;

A has a minimum value of 40 dBc, but a maximum defined value of 80 dBc.

The authorized bandwidths corresponding to the total MBS rates shall be as given in table III-1. These same authorized bandwidths shall apply when the transmitted signal corresponds to the MBS(s) listed plus a 192 Kb/s SCBS and associated modem internal overhead.

These spectral constraints for the four applicable bandwidths are illustrated in figure 3-6.

Performance level is defined by table III-1.

3.1.2.2.3.1 Allowable HPA Back-Off. In order to satisfy the RF Spectrum Occupancy requirement, the total mean emitted power after frequency upconversion and high power amplification shall be no more than two dB below the saturated output power possible for the same bandwidth adjustment of the up-converter HPA combination. Saturated output power shall mean the maximum power output for the digitally modulated signal. These requirements shall be satisfied when the modem is configured to operate with the transmitter (i.e., all stages of frequency conversion, filtering and amplification of the signal to be transmitted, between the modem and the antenna) of the AN/TRC-132A.

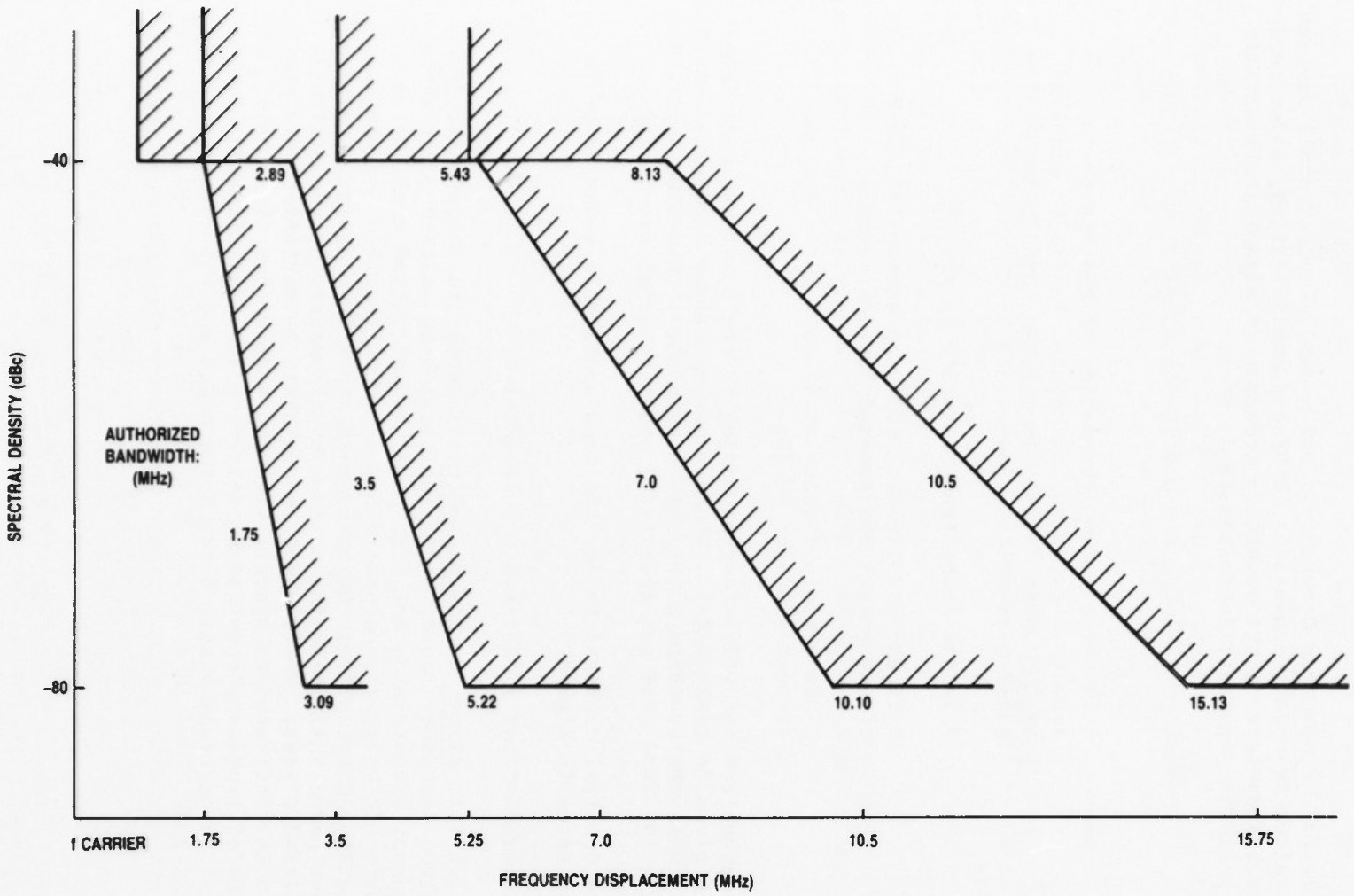


Figure 3-6. SPECTRUM OCCUPANCY MASKS FOR 1.75, 3.5, 7.0, 10.5 MHz AUTHORIZED BANDWIDTHS

Table III-1

Authorized Transmitted Bandwidth Requirements

Total MBS Rate	Bandwidth for Performance Level I	Bandwidth for Performance Level II
1.544 Mb/s	1.75 MHz	N/A
3.088 Mb/s	3.5 MHz	N/A
3.232 Mb/s	3.5 MHz	N/A
6.464 Mb/s	7.0 MHz	N/A
9.696 Mb/s	10.5 MHz	7.0 MHz

3.1.2.3 Station Clock Interface. All internal frequency generation shall be referenced to an externally supplied station clock. This clock signal will have the following characteristics:

a. 5.0 MHz stable to within one part in 10^9 or better over a 10-second interval. Long-term accuracy better than one part in 10^9.

b. 0 dBm $\pm$3 dB in 50 ohms, sinusoidal, unbalanced. All performance requirements of the modem shall be satisfied with a station clock meeting these conditions.

3.1.2.4 Input power. The modem shall operate and maintain specified performance when connected to a direct current power source which will have the following ratings:

a. Input voltage: -44 to -56 volts DC (-48 volts nominal)

b. Input wattage: 500 watts maximum

c. Noise and ripple: 100 mV maximum peak-to-peak in 10 Hz to 50 kHz

3.1.2.4.1 Power Supply Protection. All major functions shall be protected against overload separately to prevent one function from affecting others. In addition, the modem shall not be damaged or

sustain a service outage in excess of 100 msec as a result of the application of a pulse, of either polarity, of 1,000 volts peak amplitude, 1 msec width, 10 μsec rise time and 1 msec delay time applied to all input power interfaces and ground. Human intervention shall not be required to return the modem to service after the application of the specified transient.

3.1.2.5 Emission Parameters. The modem shall operate at the bit rates and bandwidths specified in table III-1 of this specification. Changes in bit rates and transmitted bandwidths may be accomplished by module or component exchange and shall be accomplished in four hours or less and require no special tools or test equipment. The use of pretuned or prealigned assemblies or components is desirable. The modem shall satisfy the emission requirements stated in 3.1.2.2.3 of this specification for the data rate and authorized transmitted bandwidth combinations specified in table III-1.

3.1.3 Major Component List

To be specified in Part 2 of the specification.

3.1.4 Government-Furnished Property List

The following items will be loaned to the contractor by the Government for test purposes:

1. Model S-236C Computer Controlled Quad Diversity Troposcatter Simulator
2. AN/TRC-132A Radio Terminal Set
3. Four FCC-99 Multiplexers
4. Two FCC-98 Multiplexers (192 Kb/s) or two FCC-100 Multiplexers (192 Kb/s)
5. Four FCC-98 Multiplexers (1.544 Mb/s)
6. Four KG-81 Trunk Encryption Devices
7. Two Walburn Frame HNF-81-2
8. One KOI-18 Tape Reader
9. PP-7507/G Power Supply Assembly

3.2 CHARACTERISTICS

3.2.1 Performance

3.2.1.1 Small Signal Performance for Fading and Dispersive Channels. When equal mean signal power is applied to the IF inputs, the modem shall provide, as a maximum, the average bit error rates (BERs) at the digital outputs for quad and dual diversity operation as given in table III-2. The "performance levels" in table III-2 correspond to the MBS rate and authorized bandwidth combinations defined in table III-1. Table III-3 lists the multipath profiles to be used.

This performance shall be achieved for the MBS and SCBS for each configuration of 3.1.2.1.1 a, b and c.

3.2.1.1.1 Doppler Bandwidth and Fade Rates. This performance shall be achieved for fading or doppler bandwidths from 0.1 Hz to 10 Hz, where the bandwidths shall be considered the 2-sigma width of the doppler spectrum.

3.2.1.1.2 Effect of Aircraft in Common Volume. An aircraft entering the common volume and introducing a specular reflection component not exceeding ten symbols in delay relative to the mean troposcatter signal shall not introduce a loss of BCI. Nor shall BCI be lost when such aircraft leaves the common volume. Furthermore, optimum bit error rate shall be established within three modem frame intervals after the aircraft either enters or leaves the common volume. Optimum bit error rate, in the case of an aircraft entering the common volume, shall be taken to mean the lowest bit error rate possible with either the modem synchronized with the troposcatter signal or the specular reflection signal and the other signal acting as interference.

In the case of an aircraft leaving the common volume, it shall be taken to mean the lowest bit error rate possible with the troposcatter signal alone.

3.2.1.2 Modem Dynamic Range. The modem dynamic range is defined as the dB difference between the mean Eb/No required for a quad diversity 3×10^{-8} BER for any profile and performance level given in table III-2 and the mean Eb/No above that level where the quad diversity BER becomes degraded from 3×10^{-8}. This dynamic range shall be a minimum of 70 dB for all profiles and both performance levels as given in table III-2.

Table III-2

Modem Small Signal Performance

Quad Diversity

Maximum Mean Eb/No (dB) for Profile

Performance Level	P1		P2		P3		P4		P5	
I	1.0	20.0	1.0	19.0	1.0	16.0	2.0	18.0	N/A	N/A
II	2.0	21.0	2.0	20.0	2.0	18.0	3.0	20.0	1.0	17.0
BER	$3X10^{-2}$	$3X10^{-8}$	$3X10^{-2}$	$3X10^{-8}$	$3X10^{-2}$	$3X10^{-8}$	$3x10^{-2}$	$3X10^{-8}$	$3x10^{-2}$	$3x10^{-6}$

Qual Diversity

Maximum Mean Eb/No (dB) for Profile

Performance Level	P1		P2		P3		P4	
I	7.0	22.0	7.0	22.0	6.0	20.0	7.0	22.0
II	10.0	24.0	10.0	24.0	9.0	22.0	9.0	25.0
BER	$3X10^{-2}$	$3X10^{-5}$	$3X10^{-2}$	$3X10^{-5}$	$3X10^{-2}$	$3X10^{-5}$	$3X10^{-2}$	$3X10^{-5}$

N/A: Not applicable

Table III-3

Multipath Profiles

	Relative Attenuation, dB				
Tap Number*	P1	P2	P3	P4	P5
1	0	0	2	0	0
2		14	2	1	OFF
3		28	9	2	2
4			15	5	OFF
5			23	9	9
6			27	13	
7				17	
8				21	
9				27	
2σ (nsec)	0	53.5	148	259	251

*Tap spacing: 100 nsec.

3.2.1.3 Modem BER Performance Floor. For a mean Eb/No 20 dB above the mean Eb/No values specified in 3.2.1.1 table III-2 for quad diversity, and 3×10^{-8} BER, the BER shall not exceed 10^{-10}.

3.2.1.4 Adjacent (Non-Contiguous) Channel Interference. The modem shall meet performance requirements specified herein with an interfering signal applied to the IF interface point 50 dB above the desired signal at any center frequency separation of twice the authorized bandwidth (table III-1) or greater from the assigned frequency. The interfering signal shall have the same power spectrum as the desired signal.

3.2.1.5 Co-Channel Interference. The modem shall provide the performance specified in table III-2 for quad diversity with less than 2 dB performance degradation for interference on each of the four IF inputs of any type within the specified authorized bandwidth having the following levels with respect to the desired signal.

a. Minus 20 dB for Performance Level I
b. Minus 25 dB for Performance Level II

3.2.1.6 Synchronization Acquisition Time. For quad diversity and a non-fading signal with a mean Eb/No corresponding to a BER of 10^{-2},

the modem shall acquire synchronization within 500 milliseconds after application of the signal to the IF interface. For the same conditions, except for a mean Eb/No corresponding to a BER of 10^{-7}, the modem shall acquire synchronization within one millisecond after application of the signal to the IF interface. For the same conditions with a mean Eb/No corresponding to a BER of 10^{-2} and the received signals and the modem TDM within ± 2 bits of synchronism, the modem shall detect loss of synchronization and reacquire synchronization within 50 milliseconds.

3.2.1.7 Maintenance of BCI. Once bit synchronization has been achieved, BCI shall be maintained for not less than one minute when the input mean Eb/No is reduced by 25 dB below the mean Eb/No specified in table III-2 for a BER of 3×10^{-8}, and when the received signal is Rayleigh fading with multipath Profile P4, a data rate of 9.696 Mb/s, a doppler bandwidth of 10 Hz, an authorized bandwidth of 7 MHz and quad diversity.

For quad diversity and a non-fading signal with a mean Eb/No corresponding to a BER of 10^{-2}, an MBS rate of 9.696 Mb/s, and an authorized bandwidth of 7 MHz, the meantime to loss of synchronization by the modem internal demultiplexer shall be greater than 24 hours.

Whenever an out-of-frame condition is detected, the output from the internal demultiplexer shall be maintained at the existing synchronization while reestablishing synchronization. When synchronization is reestablished, the modem shall switch to the new pattern; but, if the new pattern is determined to be the same as the existing pattern, then switching to the new pattern shall not cause loss of BCI.

3.2.1.8 Performance Monitoring and Alarms (Local and Remote). The modem shall include circuitry to monitor functions and provide as a minimum an alarm in the event of any failure listed below. The alarm function shall include, but not be limited to: (1) For remoting to external alarm monitoring circuitry; a 1 amp contact closure to ground, with a minimum of 75K ohms when open and a maximum of 10 ohms when closed. (2) Visible and audible alarms and an indication on the front of the modem of the nature of the failure. All of the outputs for remote monitoring shall be available at the back plane of the modem. There shall be an alarm in the event of a failure of any LRU, including the failure of any redundant LRU. In addition, the following functions shall be monitored and alarmed.

3.2.1.8.1 Data Timing Input/Output. All inputs and outputs shall be monitored for loss of data or timing (no transitions for 10 msec or more). The alarm for the unused MBS and associated timing (both inputs and outputs) shall be disabled when only one MBS is being utilized.

3.2.1.8.2 Modem Frame. The internal TDM function shall be monitored for loss of receive frame synchronization.

3.2.1.8.3 Frame Error Threshold. An alarm shall be provided which indicates when the average error rate over a 10-second interval of the internal TDM framing bits exceeds 1x10E-1.

3.2.1.8.4 Power Supply. A visible indicator shall be provided to indicate that primary power has been applied. In the event primary power is lost the indicator shall be extinguished. A second visible indicator shall light whenever any of the DC voltages from the power supply subsystem is in an under or overvoltage condition.

3.2.1.8.5 IF Output Power. Each IF output shall be monitored for a decrease or increase in IF output power of 3 dB or more relative to the selected output power between -4 and +16 dBm.

3.2.1.8.6 Overtemperature. A visible indicator shall light and an audible alarm shall sound whenever an overtemperature condition exists within the modem.

3.2.1.8.7 IF Received Signal Levels. Each IF received signal level shall be monitored. These levels shall be displayed on the front panel of the modem. They shall also be made available for remote monitoring in four-bit binary coded decimal parallel form. Each bit shall be +5 volts for a "one" and zero volts for a "zero" with standard TTL output impedance. Monitored range shall be from -10 dBm to -80 dBm for both front panel display and remoting.

3.2.1.8.8 Frame Bit Error Rate. The received framing bits in the modem shall be monitored for errors. The exponent of the BER, so determined, shall be displayed on the front panel of the modem. The integration time shall be ten seconds updated each second or 20 minutes updated each ten seconds, switch selectable for front panel display. Both of these measurements shall be made available for remote monitoring, each in four-bit binary coded decimal parallel form. Each bit shall be +5 volts for a "one" and zero volts for a "zero" with standard TTL output impedance. The monitored range of the exponent shall be from -1 to -5 for 10-second integration and -1 to -7 for 20-minute integration.

3.2.1.9 Built-In Test Equipment (BITE). The modem shall contain BITE such that, in the event of a fault alarm, the faulty LRU or LRUs (as defined in 3.2.4.1) may be identified without the need for additional tools and test equipment and in a time consistent with the requirements of section 3.2.4.

3.2.2 Physical Characteristics

3.2.2.1 Weight. The weight of the modem shall not exceed 200 pounds (91 kilograms).

3.2.2.2 Dimensions. The dimensions of the modem shall not exceed the following:

Depth	Width	Height
22	19	34 (inches)
55.9	48.3	86.4 (centimeters)

3.2.3 Reliability

The equipment shall be designed so that it meets the quantitative reliability requirements in 3.2.3.1.

3.2.3.1 Quantitative Reliability Requirements. The modem shall have a series Mean-Time-Between-Failure (MTBF) of no less than 3,000 hours. Also, the mission MTBF for the modem shall be no less than 100,000 hours. Mission success shall require that the modem process at least two out of four IF input signals and the single or dual MBS(s) and the 192 Kb/s service channel.

3.2.3.2 Reliability Predictions. The reliability prediction shall show predicted reliability parameters equal to, or greater than, those specified in 3.2.3.1.

3.2.3.3 Reliability Definitions. Reliability terms shall be defined in accordance with MIL-STD-721 and MIL-STD-781 unless specifically modified herein. In the event of conflicts of interpretation, the definitions contained herein shall have precedence followed by the "Definitions" and "Failure Categories" requirements of MIL-STD-781 and MIL-STD-721, in that order.

3.2.3.3.1 Series MTBF. Series MTBF is the mean operating time between relevant failures for the series combination of all applicable parts and/or equipment included in this specification. In computing series MTBF, the total of all scheduled operating times divided by the total number of relevant failures which occurred during all scheduled operating times shall be used.

3.2.3.3.2 Mission MTBF. Mission MTBF is the mean time between mission relevant failures. In computing mission MTBF, the total scheduled operating time divided by the total number of mission relevant failures which occurred during all scheduled operating times shall be used.

3.2.4 Maintainability

The equipment shall be designed so that it meets the quantitative maintainability requirements in 3.2.4.1. Definition of the maintainability terms shall be in accordance with MIL-STD-721 unless otherwise defined in this specification.

3.2.4.1 Quantitative Maintainability Requirements. The Mean-Corrective-Maintenance-Time (Mct) for the modem shall not be greater than fifteen (15) minutes. The Maximum-Corrective-Maintenance-Time (Mmaxct) for the modem shall not be greater than forty-five (45) minutes at the 95th percentile. The corrective maintenance times are based on correction of faults by removal/replacement of Line Replaceable Units (LRU). An LRU is defined as being a part, subassembly, or assembly that is replaceable by operator and/or maintenance personnel at the operation location. Wherever possible an LRU shall be a printed circuit board or card. A group or set of cards shall not be considered an LRU. There shall be no downtime permitted to perform preventive maintenance. Preventive maintenance shall be performed off-line on redundant items or during periods of reduced activity and shall not interrupt or interfere with mission success or the modem operation. Preventive maintenance shall not be necessary more frequently than every 1500 hours.

3.2.4.1.1 Mean-Corrective-Maintenance-Time (Mct). The Mct for the modem is defined as the total repair time due to relevant failures as defined in 3.2.3.3.1 divided by the total number of relevant failures of the modem. This repair time shall include that time required to detect and isolate the failure, replace the failed component, check out the repair, and return the equipment to full operational status as specified by the performance requirements defined in 3.2.

3.2.4.1.2 Maximum-Corrective-Maintenance-Time (Mmaxct). The Mmaxct for the modem is defined in accordance with MIL-HDBK-472. Mmaxct is the maximum repair time following a relevant failure as defined in 4.2.12.

3.2.4.2 Accessibility of LRUs. All LRUs shall be accessible from the front of the modem or by pulling out a drawer. The LRUs shall be removable without extensive disassembly. Repeated removal and insertion of PC boards and movement of them in the rack shall cause no change in performance of the modem.

3.2.5 Environmental Conditions

The modem shall meet all performance requirements cited in this specificstion under the conditions specified in the ensuing paragraphs and shall suffer no failure, deterioration or change in tolerance limits which could in any manner prevent it from meeting operational tolerance limits or which could in any manner prevent it from meeting operational service or maintenance requirements.

3.2.5.1 Altitude. The modem shall be operable without degradation in specified performance at altitudes up to 10,000 feet above sea level and shall withstand transportation in aircraft st altitudes up to 40,000 feet above sea level.

3.2.5.2 High Temperature. The modem shall meet all specified performance requirements at ambient air temperatures as high as +52 degrees C (+125 degrees F). The equipment shall withstand exposure, during storage and/or transit, to ambient air temperature as high as +71 degrees C (+160 degrees F).

3.2.5.3 Low Temperature. At an ambient temperature of -32 degrees C (-25 degrees F), the modem shall be capable of providing full specified performance. The modem shall withstand exposure during storage and/or transit, to ambient air temperatures as low as -57 degrees C (-70 degrees F).

3.2.5.4 Humidity. The modem when non-operating shall be capable of withstanding humidity up to 100%, including condensation due to temperature change. When operating it shall satisfy all performance requirements with humidity up to 95% with a temperature of 27^{o}C (+80^{o}F) including condensation due to temperature change.

3.2.5.5 Fungus. The modem shall be capable of prolonged exposure to tropical conditions without degradation of material surfaces or performance.

3.2.5.6 Vibration. The modem, when packaged for shipment, shall be capable of withstanding the vibration associated with transportation over all types of roads, cross country terrain, water, and by fixed and rotary winged aircraft.

3.2.5.7 Shock. The modem, when packaged for shipment, shall be capable of withstanding the shock associated with transportation by rail, water, and air. The modem and its subassemblies shall also withstand the shock associated with bench handling.

3.2.6 Transportability

The modem when packaged for shipment shall withstand the effect of transport by fixed-wing cargo aircraft, military helicopters, military cargo vehicles and trailers, rail, and sealift.

3.3 DESIGN AND CONSTRUCTION

3.3.1 Materials, Processes and Parts

All materials, processes and parts selected for use shall comply with the following in order of precedence:

This Specification

MIL-E-4158

MIL-STD-454

MIL-STD-143

3.3.1.1 Parts. All parts employed in the manufacture of newly designed or modified items (modified portion only) for the modem shall be selected in accordance with the Program Parts Selection List, Electrical/Electronic Parts and the Program Parts Selection List, Mechanical Parts. Parts not covered by the above mentioned PPSLs shall be selected IAW MIL-E-4158 and MIL-STD-965.

All parts shall be screened through the Government/Industry Data Exchange Program (GIDEP) Failure Experience Data Bank (FEDB) prior to their selection. In addition, all parts shall be derated in accordance with ESD-TR-83-197.

3.3.1.1.1 Semiconductors. All semiconductors shall be selected IAW Requirement 30 of MIL-STD-454 and the following:

a. Only solid glass metallurgically bonded axial lead diodes and rectifiers shall be used.

b. When TO-5 packages are required, they shall be limited to the solid metal header type.

c. Thermocompression wedge bonding shall not be used with aluminum wire.

d. Aluminum TO-3 packages shall not be used.

e. Germanium devices shall not be used.

f. All non-JAN TX devices shall be screened in accordance with the JAN-TX screens of table II of MIL-S-19500. All device types shall be tested to the Group A, table III and Group B, table IV quality conformance requirements of MIL-S-19500, as a minimum.

g. Semiconductor devices not covered by ESD-TR-83-197 shall not have peak junction temperatures exceeding the following when operated under any specified environmental conditions.

(1) Power devices = 135 degrees C (275 degrees F)

(2) Small signal devices = 125 degrees C (257 degrees F)

3.3.1.1.2 Microcircuit Devices

3.3.1.1.2.1 Critical Items. Hybrid (including radio frequency, microwave and millimeter types) and complex and newly designed (less than one year from release) monolithic microcircuits are considered critical items.

3.3.1.1.2.2 All Microelectronic Devices shall be selected IAW with Requirement 64 of MIL-STD-454 and the following.

3.3.1.1.2.3 Microelectronic Devices not covered by ESD-TR-83-197 shall not have peak junction temperatures exceeding 125 degrees C (257 degrees F) when operated under any specified environmental conditions.

3.3.1.1.2.4 All non-JAN devices shall be tested in accordance with MIL-STD-883, method 5004 or 5008 as applicable. All devices shall be tested to the quality conformance requirements of MIL-STD-883 methods 5005 and 5008 as applicable. No waivers are allowed except current and valid generic data as defined below in 3.3.1.1.2.4.1 may be substituted for Groups C and D.

3.3.1.1.2.4.1 Group C generic data must be on date codes no more than one year old and on a die in the same microcircuit group (see appendix E of MIL-M-38510) with the same material, design, processes and from the same plant as the die represented. Group D generic data must be on date codes no more than one year old and on the same package type (see 3.1.3.12 of MIL-M-38510) and from the same plant as the package represented.

3.3.1.1.3 Printed Wiring Assemblies. This section is not applicable to this specification.

3.3.1.1.4 Corrosion of Metal Parts. Construction techniques shall ensure that metal parts will not be subject to corrosion. The use of dissimilar metals in immediate contact, which may result in electrolytic corrosion in the presence of moisture, shall be avoided, and they shall be adequately insulated. Design of metal parts shall be in accordance with MIL-STD-454, Requirements 15 and 16.

3.3.1.1.5 Finish. The modem shall be given a protective finish, in accordance with MIL-F-14072. The exterior surface of the modem shall be painted with light gray enamel, color 26250 of FED-STD-595. The finish shall not be of the wrinkle type.

3.3.1.1.6 Conformal Coating. This section is not applicable to this specification.

3.3.1.1.7 Poly-Vinyl Chloride. Poly-Vinyl Chloride (PVC) shall not be used in the modem or in any part or component of the modem.

3.3.2 Electromagnetic Radiation

The modem shall comply with the conducted and radiated emission and susceptibility requirements of MIL-STD-461, Part 4, paragraphs 3, 7, 11, 14, 15, 18, and 19.

3.3.2.1 Electromagnetic Compatibility. The modem shall be electromagnetically compatible with all its subassemblies and with the equipment listed in 3.1, as well as with other equipments such as air conditioners and heaters with which it may be required to operate. AFSC Design Handbook 1-4, Electromagnetic Compatibility, shall be used for general design guidance and criteria.

3.3.2.2 Bonds, Grounds, Shields and Connectors. Bonding for equipment current path return, RF potentials and shock hazard shall be so installed that expansion, contraction, or movement incident to normal service use will not break or loosen the connections.

Surface preparation for bonds and grounds shall be accomplished by removing all anodic film, grease, paint, lacquer, or other high resistance substances from the immediate area of contact. Bonding impedance shall not exceed 2.5 milliohms. Case and chassis mounted connectors shall have an approved RF conductive finish. Bonding impedance, as measured from the connector case or chassis, shall not exceed 2.5 milliohms. Specification MIL-B-5087 shall apply. Upon installation of the bonding assembly and ascertainment of the required 2.5 milliohms bonding impedance, the surrounding equipment surface shall be restored in accordance with MIL-F-14072. Coaxial cables, as required, shall be of the double shielded type. Other cables requiring overall shielding shall have a minimum of ninety percent coverage. The shield shall be constructed of tinned copper braid. Cable connectors for use with shielded cables shall have an approved RF conductive finish and shall be provided with EMI back-shells for peripheral bonding of the cable shield. All input and output connectors shall be in accordance with MIL-C-21097.

3.3.3 Nameplates and Product Marking

All identification and markings shall be in accordance with MIL-STD-130.

3.3.3.1 Nameplate. The modem nameplate shall include the contract number, official nomenclature of the modem, and the names of the developmental agency and contractor.

3.3.3.2 Marking and Identification. All markings and stencils shall be permanent and legible.

3.3.3.3 Reference Designation Marking. Each and every electrical component shall be identified in the equipment and in supporting documentation (technical orders) by a reference designation (R18, C101, L6, etc.). The marking shall be immediately adjacent to the physical location of the component in the equipment and readily visible to maintenance personnel. In the event space limitations make it impractical to stencil a chassis, then a permanently mounted chart showing all reference designations shall be mounted nearby.

All fuses approved for use shall be clearly and fully identified as to size, rating, function, etc. If it can be clearly demonstrated that it is impractical or impossible to mark certain components in the manner specified, alternate markings may be used, if approved.

3.3.3.4 Cable and Receptacle Marking. Each cable shall have a permanent band and each receptacle shall have a stencil giving reference designators; additional markings shall be provided to identify mating receptacles or connectors.

3.3.3.5 Terminal Strips. All terminal strips shall have each terminal properly numbered with a permanent type stencil. All wires leading thereto shall be identified with either a permanent numbered sleeve, tags or the equivalent.

3.3.4 Workmanship

Workmanship shall conform to Requirement 9 of MIL-STD-454.

3.3.5 Interchangeability

Interchangeability shall be in accordance with Requirement 7 of MIL-STD-454. The LRUs shall be interchangeable between modems without requiring further alignment.

3.3.6 Safety

The modem shall be designed to prevent injury to personnel or equipment during implementation, operation and maintenance. The personnel safety shall conform to the requirements of MIL-STD-454, Requirement 1. Positive consideration shall be given but not be limited to the following.

3.3.6.1 Mechanical. Sharp projections and overhanging edges or protrusions shall be avoided.

3.3.6.2 Low Voltage. With the modem assembled and in operation, personnel shall be protected from contact with potentials in excess of 20 volts to ground, chassis or frame, including potentials on charged capacitors.

3.3.6.3 High Voltage. Interlocks or other physical/mechanical protection shall be provided to prevent access to the interior of the modem, or components thereof, without removal of all voltages exceeding 130 volts between any two points of the equipment or between any point and ground. Interlocks shall conform to MIL-P-11268.

3.3.6.4 Warning Labels. Where a voltage of 115 or more volts nominal value is exposed during maintenance, a warning label shall be provided denoting the nominal voltage exposed.

3.3.6.5 Connectors. Where connectors are utilized on the chassis or panel, they shall be recessed to prevent personnel injury or connector damage or breakage.

3.3.7 Human Performance/Human Engineering

MIL-STD-1472 and MIL-H-46855 shall be used as the human engineering design criteria to maximize military effectiveness and to minimize demands upon human skill, training and personnel.

3.4 DOCUMENTATION

Documentation shall be provided in accordance with the Statement of Work.

3.5 LOGISTICS

3.5.1 Maintenance

Two categories of maintenance will be performed, on-equipment and off-equipment. Equipment shall be modular in design with built-in test to each LRU. On-equipment repair will include removal and replacement to the LRU level. On-equipment will be conducted IAW AFR 66-1 and AFR 66-14. Off-equipment, off-site maintenance will be required for the failed LRUs.

3.5.2 Supply

Considerations of introduction of new components into the supply system, supply and resupply methods, and distribution and location of item stocks will be included in the RFP package and will be made part of the contract.

3.5.3 Facilities and Facility Equipment

This section is not applicable to this specification.

3.6 PERSONNEL AND TRAINING

3.6.1 Personnel

The modem shall be designed for installation (into a radio terminal), operation and on-equipment maintenance by skill level five personnel. Installation shall require no more than two such personnel. Operation and on-equipment maintenance shall require no more than one such person.

3.6.2 Training

The contractor shall provide training in accordance with the RFP package.

3.7 MAJOR COMPONENT CHARACTERISTICS

To be specified in Part 2 of the specification.

3.8 PRECEDENCE

In case of conflict, the requirements of this specification shall take precedence over all other documents referenced herein.

SECTION 4

QUALITY ASSURANCE PROVISIONS

4.1 GENERAL

Compliance with operational parameters shall be determined from Government-approved test plans, test procedures, and test reports as required by the CDRL and the requirements of AFSC DH4-2.

4.1.1 Responsibility for Tests

The contractor shall be responsible for accomplishment of each test and verification required herein, unless otherwise specified in the contract or purchase order. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that all supplies and services conform to prescribed requirements.

4.1.2 Special Tests and Examinations

4.1.2.1 Environmental Stress Screening. Prior to acceptance testing, the contractor shall conduct stress tests consisting of power cycling and thermal cycling (reference MIL-STD-781) over the temperature range -25° to 160°F. The number of thermal cycles is a critical factor rather than the specific number of hours in a single cycle. The cycle length, while being determined by the equipment-chamber temperature stabilization at the high and low extremes, should be as short as practical but not to induce severe thermal shock to the modem (rate of chamber temperature change shall average 9°F/minute).

Performance parameters shall be measured during the stabilization period after the first cold to hot transition and once thereafter (once a working day thereafter if this testing extends beyond one day). There shall be ten (10) temperature cycles. The modem shall be in a power-on status during heat increase and a power-off status during cooling.

Random vibration screening shall be performed on the modems. The modem under test shall be hand mounted to a shake table, oriented on the fixture such that the axis of vibration is perpendicular to the

printed circuit boards. Where electronic components in the equipment under test are oriented in more than one (1) plane, such equipment should be shaken sequentially in each of three (3) orthogonal axes.

The duration of random vibration shall be at least ten (10) minutes if a single axis is sufficient. Where vibration in more than one axis is required, the duration of random vibration shall be at least five (5) minutes for each axis. The random vibration shall be in accordance with MIL-STD-781, paragraph 4.4.1.

Each non-mechanical card/board delivered as a spare shall be subjected to twelve (12) non-operating thermal cycles (-70^{o}F to $+160^{o}$F). Each thermal cycle shall be four (4) hours in duration (two (2) hours hot, two (2) hours cold). Complete testing, in accordance with the contractor's internal test specifications (applicable to each card/board), shall be accomplished prior to and following the thermal cycling. Any card/board that fails these tests after completion of the thermal cycling shall be repaired and subjected again to the thermal cycling.

4.1.2.2 Compatibility With the AN/FRC-96 and AN/TRC-132A Radios. Compatibility of the modem with the AN/FRC-96 Radio shall be verified by analysis of the technical documentation of that radio. The contractor shall identify modifications and adjustments to that radio which may be necessary in order for the modem to interface with that radio without performance degradation.

Compatibility of the modem with the AN/TRC-132A Radio shall be verified by the tests described herein. Although the modem IF interface impedance is 50 ohms and the AN/TRC-132A IF interface impedance is 75 ohms, the compatibility may be effected by the use of external 50 ohm to 75 ohm matching pads (impedance transformers), which the contractor shall supply.

4.1.3 Qualification Verifications

Qualification verifications shall demonstrate and verify compliance of the modem with the requirements of this specification. The Qualification verifications are to be performed on the first four models produced (first article tests). The Qualification verifications are to include all tests under 4.2 of this specification.

4.1.4 Production Acceptance Test and Evaluation (PAT&E)

The PAT&E are tests which are reduced in scope from the first article tests of the Qualification test. Environmental Stress Screening and a PAT&E Test shall be performed on the production models and the refurbished first article models to verify their compliance with the requirements of this specification.

4.1.5 Verification Summary

A summary of verifications to be performed on the modem, is given in table IV-1. This table includes: the verification method (test, inspection or analysis, as defined below); test classification (minor, major or critical as defined in MIL-STD-109); the requirement paragraph of section 3; the QA provision paragraph of section 4, the frequency of test under PAT&E (universal, selective, one time, as defined in the SOW).

a. Test. Formal verification of equipment parameters/requirements to demonstrate compliance with performance and allocated configuration baseline specifications. Such verification is formally witnessed by appropriate Government representatives and is conducted according to contractor and/or subcontractor-prepared and Government-approved test procedures. Test results shall be formally recorded via contractor prepared and Government-approved test reports.

b. Inspection. Physical and visual measurements or examination made under fully controlled and traceable conditions. Inspection, as defined herein, may be used to demonstrate compliance with a specification paragraph or subparagraph. When so used, it shall be outlined in the appropriate test plan/procedure submitted to the Government in compliance with the Contractor's Data Requirements List (CDRL). The results of inspection shall be recorded and shall be included in the appropriate test report provided to the Government in compliance with the CDRL.

c. Analysis. All mathematical and/or analytical examination of data. Analysis as defined herein, may be used to demonstrate compliance with a specification paragraph or subparagraph. When so used, it shall be outlined in the appropriate test plan/procedure submitted to the Government in compliance with the CDRL.

Table IV-1

Test Summary

SECTION 3 Paragraph	Requirement	VERIFICATION Method	Classification	SECTION 4 Paragraph	Frequency
3.	REQUIREMENTS			N/A	
3.1	ITEM DEFINITION			N/A	
3.1.1	Item Diagrams			N/A	
3.1.2	Interface Definition	A	Major	4.1.2.2	OT
3.1.2.1	Oigital Interface			N/A	
3.1.2.1.1	Ceneral	T	Major	4.2.3.3	U
3.1.2.1.2	Data and Clock Input/Output Signals	T	Major	4.2.3.3	OT
3.1.2.1.3	Multiplexer Clock Source and Timing Offset	T	Major	4.2.3.4	OT
3.1.2.1.3.1	Two MBS with Timing Offset	T	Major	4.2.3.4	OT
3.1.2.1.4	Oigital Input/Output Signal Characteristics	T	Major	4.2.3.3	S
3.1.2.1.5	Output Voltage Level	T	Major	4.2.3.3	U
3.1.2.1.6	Output Rise and Fall Times	T	Major	4.2.3.3	U
3.1.2.1.7	Output Oata/Timing Relationships	T	Major	4.2.3.3	U
3.1.2.1.8	Output Jitter	T	Major	4.2.3.3	U
3.1.2.1.9	Input and Output Impedance	T	Major	4.2.3.3	U
3.1.2.1.10	Input Voltage Level	T	Major	4.2.3.5	U
3.1.2.1.11	Input Combined Effects of Jitter	T	Major	4.2.3.6	S
3.1.2.1.12	Lockup Protection	T	Major	4.2.3.15	OT
3.1.2.1.13	Interface Protection	T	Major	4.2.3.16	OT
3.1.2.1.14	Internal Time Oivision Multiplexer (TOM)	T	Major	4.2.3.3	S
3.1.2.1.15	Internal Time Oivision Oemultiplexing and Timing	T	Major	4.2.3.4.1	OT
3.1.2.1.16	Frame Search Inhibit (FSI) Command	T	Major	4.2.3.8	OT
3.1.2.2	IF Interface			N/A	
3.1.2.2.1	Transmit Modem Level and Impedance	T	Major	4.2.3.1	U
3.1.2.2.2	Receive Modem Level and Impedance	T	Major	4.2.3.2	U
		T	Major	4.2.3.12	U
3.1.2.2.3	RF Spectrum Occupancy	T	Major	4.2.3.7.4	OT
3.1.2.2.3.1	Allowable HPA Back-Off	T	Minor	4.2.3.7.4	OT
3.1.2.3	Station Clock Interface	T	Major	4.2.3.10	OT
3.1.2.4	Input Power	T	Major	4.2.5	OT
3.1.2.4.1	Power Supply Protection	A	Minor	4.2.6	OT
3.1.2.5	Emission Parameters	T	Minor	4.2.7	OT
3.1.3	Major Component List			N/A	
3.1.4	Covernment-Furnished Property List			N/A	
3.1.5	Covernment-Loaned Property List			N/A	
3.2	CHARACTERISTICS			N/A	

Table IV-1 (Continued)

SECTION 3 Paragraph	Requirement	VERIFICATION Method	Classification	SECTION 4 Paragraph	Frequency
3.2.1	Performance			N/A	
3.2.1.1	Small Signal Performance for Fading and Dispersive Channels	T	Major	4.2.3.7.1	S
				4.2.3.7.2	S
				4.2.3.7.3	S
3.2.1.1.1	Doppler Bandwidth and Fade Rates	T	Major	4.2.3.7.1	S
				4.2.3.7.2	S
				4.2.3.7.3	S
3.2.1.1.2	Effect of Aircraft in Common Volume	T	Minor	4.2.3.7.5	S
3.2.1.2	Modem Dynamic Range	T	Major	4.2.3.11	S
3.2.1.3	Modem BER Performance Floor	A	Minor	4.2.3.12	OT
3.2.1.4	Adjacent (Non-Contiguous) Channel Interference	T	Minor	4.2.3.13	OT
3.2.1.5	Co-Channel Interference	T	Minor	4.2.3.14	OT
3.2.1.6	Synchronization Acquisition Time	T	Major	4.2.3.8	OT
3.2.1.7	Maintenance of BCI	T	Major	4.2.3.19	S
3.2.1.8	Performance Monitoring and Alarms (Local and Remote)			N/A	
3.2.1.8.1	Data Timing Input/Output	T	Minor	4.2.4.1	S
3.2.1.8.2	Modem Frame	T	Minor	4.2.4.2	S
3.2.1.8.3	Frame Frror Threshold	T	Minor	4.2.4.3	S
3.2.1.8.4	Power Supply	T	Minor	4.2.4.4	U
3.2.1.8.5	IF Output Power	T	Minor	4.2.4.5	U
3.2.1.8.6	Overtemperature	T	Minor	4.2.4.6	U
3.2.1.8.7	IF Received Signal Levels	T	Minor	4.2.4.7	U
3.2.1.8.8	Frame Bit Error Rate	T	Minor	4.2.4.8	U
3.2.1.9	Built-In Test Equipment	T	Minor	4.2.14	OT
3.2.2	Physical Characteristics			N/A	
3.2.2.1	Weight	T	Minor	4.2.8	OT
3.2.2.2	Dimensions	I	Minor	4.2.9	OT
3.2.3	Reliability			N/A	
3.2.3.1	Quantitative Reliability Requirements	T&A	Major	4.2.10	OT
3.2.3.2	Reliability Predictions	A	Minor	4.2.10	OT
3.2.3.3	Reliability Definitions			N/A	
3.2.3.3.1	Series MTBF			N/A	
3.2.3.3.2	Mission MTBF			N/A	
3.2.4	Maintainability			N/A	
3.2.4.1	Quantitative Maintainability Requirements	T	Minor	4.2.14	OT
3.2.4.1.1	Mean-Corrective-Maintenance-Time (Mct)	T	Minor	4.2.14	OT
3.2.4.1.2	Maximum-Corrective-Maintenance-Time (Mmaxct)	T	Minor	4.2.14	OT
3.2.4.2	Accessibility of LRUs	T	Minor	4.2.14	OT
3.2.5	Environmental Conditions			N/A	

Table IV-1 (Continued)

SECTION 3 Paragraph	Requirement	VERIFICATION Method	Classification	SECTION 4 Paragraph	Frequency
3.2.5.1	Altitude	T	Minor	4.2.1.1	OT
3.2.5.2	High Temperature	T	Minor	4.2.1.2	OT
3.2.5.3	Low Temperature	T	Minor	4.2.1.3	OT
3.2.5.4	Humidity	T	Minor	4.2.1.4	OT
3.2.5.5	Fungus	A	Minor	4.2.1.5	OT
3.2.5.6	Vibration	T	Minor	4.2.1.6	OT
3.2.5.7	Shock	T	Minor	4.2.1.6	OT
3.2.6	Transportability	T	Minor	4.2.1.6	OT
3.3	DESIGN AND CONSTRUCTION			N/A	
3.3.1	Materials, Processes and Parts			N/A	
3.3.1.1	Parts	I	Minor	4.2.15	U
3.3.1.1.1	Semiconductors	I	Minor	4.2.15	U
3.3.1.1.2	Microcircuit Devices	I	Minor	4.2.15	U
3.3.1.1.3	Printed Wiring Assemblies			N/A	
3.3.1.1.4	Corrosion of Metal Parts	A	Minor	4.2.15	OT
3.3.1.1.5	Finish	I	Minor	4.2.17	U
3.3.1.1.6	Conformal Coating			N/A	
3.3.1.1.7	Poly-Vinyl Chloride	I	Critical	4.2.15	S
3.3.2	Electromagnetic Interference	T	Minor	4.2.3.17	U
3.3.2.1	Electromagnetic Compatibility	T	Minor	4.2.3.17	U
3.3.2.2	Bonds, Grounds, Shields, Connectors	I	Minor	4.2.17	U
		T	Minor	4.2.2	U
		T	Minor	4.2.2.1	U
		T	Minor	4.2.2.2	U
		T	Minor	4.2.2 3	U
3.3.3	Nameplates and Product Marking			N/A	
3.3.3.1	Nameplate	I	Minor	4.2.16	U
3.3.3.2	Marking and Identification	I	Minor	4.2.16	U
3.3.3.3	Reference Designation Marking	I	Minor	4.2.16	U
3.3.3.4	Cable and Receptacle Marking	I	Minor	4.2.16	U
3.3.3.5	Terminal Strips	I	Minor	4.2.16	U
3.3.4	Workmanship	I	Minor	4.2.17	U
3.3.5	Interchangeability	I	Minor	4.2.18	U
3.3.6	Safety	I	Critical	4.2.19	U
3.3.6.1	Mechanical	I	Critical	4.2.19	U
3.3.6.2	Low Voltage	I	Critical	4.2.19	U
3.3.6.3	High Voltage	I	Critical	4.2.19	U
3.3.6.4	Warning Labels	I	Critical	4.2.19	U

The results of analysis shall be included in the appropriate test report provided to the Government in compliance with the CDRL.

4.2 QUALITY CONFORMANCE INSPECTIONS

All performance and design requirements of the modem including performance characteristics, shall be verified by analysis, inspection or test. Verification of all requirements specified in Section 3 and its subparagraphs shall be accomplished. Unless otherwise specified, e.g., environmental tests, all tests required by this specification shall be made under the prevailing ambient conditions at the test locations selected (whether factory or field sites). Test Reports on the tests of the following subparagraphs shall be submitted in accordance with the Contractor Data Requirements List, Form 1423.

4.2.1 Environmental Tests

Test methods and procedures shall be in accordance with the provisions of MIL-STD-810. Inspection, measurement and demonstration tests shall be conducted in an actual operating, non-operating or storage mode, as appropriate, to verify compliance with the requirements specified in 3.2.5. Test configurations are defined as follows:

a. Operating: The modem shall be set up for normal operation with the equipment energized.

b. Non-Operating: Same as "Operating" except that the modem is not energized.

c. Transport/Storage: The modem shall be packaged for shipment.

The following tests shall be performed on the modem in order to determine compliance with the requirements of 3.2.5.

4.2.1.1 Altitude. The equipment shall be subjected to the test of Method 500.1, Procedure I of MIL-STD-810.

a. Pretest data is required (3.2.1 of MIL-STD-810).

b. In step 2, the equipment shall be subject to chamber pressure altitude of both 40,000 ft. (non-operating) and 10,000 ft. (operating) for a period of not less

than one hour at each pressure altitude. The equipment shall be operated for a period of one hour and appropriate measurements made at the 10,000 ft. pressure altitude.

4.2.1.2 High Temperature. The modem shall be subjected to the test of Method 501.1, Procedure I of MIL-STD-810. In step 4 the highest operating temperature shall be 125°F. In step 5, the modem shall be operated for a period of one hour before measurements are taken.

4.2.1.3 Low Temperature. The modem shall be subjected to the test of Method 502.1, Procedure I of MIL-STD-810, except that step 3 shall be deleted. In step 2 the storage temperature shall be maintained for a period of 2 hours after stabilization. The lowest operating temperature in step 4 shall be -25 degrees F. In step 5 the modem shall be operated for a period of one hour and then performance measurements made.

4.2.1.4 Humidity. The modem shall be subjected to the test of Method 507.1, Procedure II of MIL-STD-810. Prior to measurements, excess surface water may be removed by wiping external surfaces only.

4.2.1.5 Fungus. Analyze the specifications of all materials exposed to the atmosphere to verify that only inherently fungus resistant grades of materials in accordance with MIL-STD-454, Requirement 4, have been used.

4.2.1.6 Shock and Vibration. The modem packaged for shipment is to be subjected to six impact shocks of 15 g's at a time duration of 11 milliseconds. One shock is to be applied in each direction along the three major axes of the equipment. Verify post shock tests show no visual, mechanical, or electrical degradation or failure.

The modem, packaged for shipment, is to be subjected to a simple harmonic motion, having an amplitude of 0.015 inches (0.030 inches maximum excursion). This frequency is to be varied uniformly between the approximate limits of 10 to 55 Hz. The rate of frequency change is to be linear and such that the complete cycle (10-55-10) takes 30 minutes.

One cycle is to be performed along each of the three major axes of the equipment. Verify that post vibration tests show no visual, mechanical or electrical degradation or failure.

4.2.1.7 Bench Handling. All LRUs of the modem and the modem itself shall be subjected to MIL-STD-810, Method 516.2 Procedure V.

4.2.2 Electrical Tests

The modem shall be given all electrical tests necessary to confirm that all circuits are inherently sound and in compliance with the requirements of this specification. The electrical tests shall include, but not necessarily be restricted to, the following.

4.2.2.1 Continuity. Each electrical component and each cord and cable shall be given a continuity test to ascertain if it is wired and connected correctly.

4.2.2.2 Electrical Measurements. Measurements of voltage from all test points, connector terminals, and all other pertinent points to ground shall be made with all controls set for normal operation. Resistance from the above points to ground shall be measured and recorded with all controls set for normal operation, but with no power applied. Using instruments of the vacuum tube-voltmeter type, each circuit element shall be checked for voltage, current, resistance or wattage rating and operating temperature as applicable. Tolerance limits shall be checked to determine that circuit elements have been selected in accordance with the requirements of each application.

4.2.2.3 Operating Voltage. The operating voltage at all important points shall be checked for conformance to those shown on the circuit label. This shall be done with all controls set for normal operation.

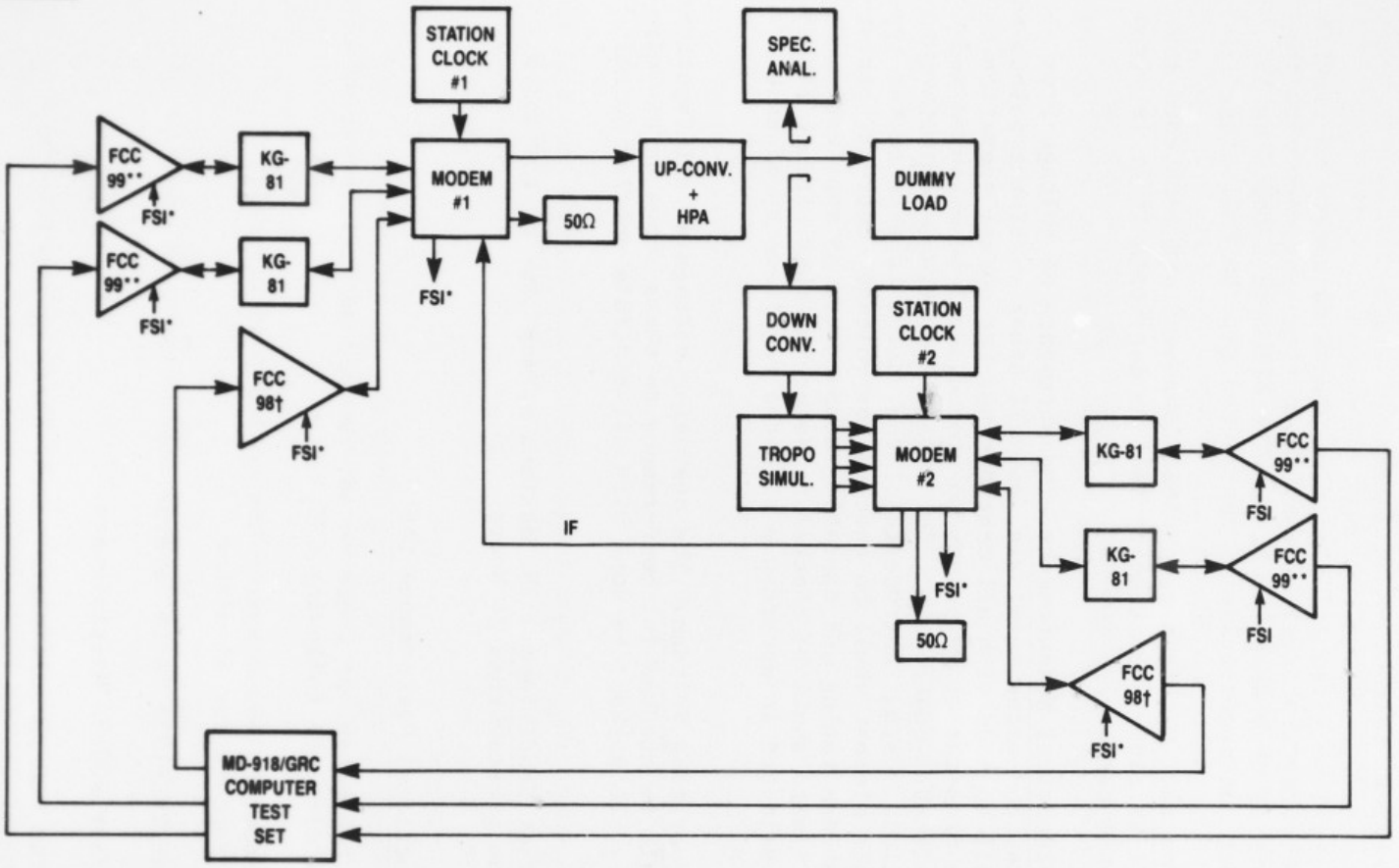
4.2.2.4 Test Conditions. The maximum warmup time of the modem shall be no greater than 24 hours.

4.2.3 Functional Performance Tests

For these tests, except where noted, two modems will be set up as in figure 4-1 with the following GFE:

1. Model S-236C Computer Controlled Quad Diversity Troposcatter Simulator
2. AN/TRC-132A Radio Terminal Set
3. Four FCC-99 Multiplexers
4. Two FCC-98 Multiplexers (192 Kb/s) or two FCC-100 Multiplexers (192 Kb/s)

IA-69,161



*FSI = FRAME SEARCH INHIBIT
**OR FCC-98
†OR FCC-100

Figure 4-1. FUNCTIONAL PERFORMANCE TEST — CONCEPTUAL BLOCK DIAGRAM

5. Four FCC-98 Multiplexers (1.544 Mb/s)

6. Four KG-81 Trunk Encryption Devices

7. Two Walburn Frame HNF-81-2

8. One KOI-18 Tape Reader

9. PP-7507/G Power Supply Assembly

The contractor shall supply all other equipment needed.

4.2.3.1 Transmit Level. Measure the modem IF transmit level, impedance and frequency. Verify compliance with the requirements.

4.2.3.2 Receive Level. Measure the modem IF receive impedance at the required frequency. Performance over the required dynamic range will be tested in 4.2.3.11.

4.2.3.3 Data/Clock I/O Signal Configuration. Set up the two modems in a back-to-back configuration, i.e., as in figure 4-1, but with the two modems connected directly (except for level adjustment equipment and power dividers) at IF. Each IF output of each modem shall be connected via a power divider to two IF inputs of the other modem. Measure all electrical characteristics of clock and data input and output signals. Verify that temporal relationships of output data and timing signals and their rise and fall times are in accordance with requirements. Verify that interruption of one or more digital inputs, when the modem is configured for multiple inputs, does not affect the performance of the modem with respect to the remaining inputs for all possible combinations. These tests shall be performed for the following baseband multiplexer/KG-81 configurations interfacing with each modem.

a. Two FCC-99s, one FCC-98, (or FCC-100), two KG-81s, each MBS at 3.232 Mb/s

b. Two FCC-99s, one FCC-98 (or FCC-100), each MBS at 3.232 Mb/s

c. One FCC-99, one FCC-98 (or FCC-100). MBS at 9.696 Mb/s, authorized bandwidth of 10.5 MHz (Performance Level I)

d. One FCC-99, one FCC-98 (or FCC-100), one KG-81 MBS at 9.696 Mb/s, authorized bandwidth of 7.0 MHz (Performance Level II)

e. One FCC-98 (or FCC-100), but modem configured for (d) above

f. Two FCC-98s, each providing an MBS of 1.544 Mb/s and one FCC-98 (or FCC-100) providing a SCBS of 192 Kb/s

4.2.3.4 Multiplexer Clock Source Timing. With the back-to-back configuration of 4.2.3.3 a., use two frequency synthesizers locked to the station clock to offset one MBS transmit data and timing signal into modem 1 by $+5 \times 10^{-8}$ relative to the station clock, and the other MBS transmit data and timing signals by -5×10^{-8}. Verify no loss of BCI in 14 minutes.

4.2.3.4.1 Offset Between Station Clocks. With the back-to-back configuration of 4.2.3.3 a., use one station clock for modem 1 and use a frequency synthesizer locked to the station clock to supply an offset station clock input to modem 2. Operate for a combination of time and offset to verify compliance with 3.1.2.1.15.

4.2.3.5 Digital Input Voltage Level Variations. With the back-to-back configuration of 4.2.3.3 a., vary digital input levels within required bounds and verify by measurement that no change in performance occurs. Demonstrate that input voltage levels of $\pm$14 volts cause no damage to the modem.

4.2.3.6 Input Combined Effects of Jitter. Using back-to-back configuration of 4.2.3.3 a., verify by test that specified maximum peak timing to peak data digital inputs causes no degradation in performance.

4.2.3.7 Small Signal Performance

4.2.3.7.1 Qualification Tests. Except as indicated in table IV-2, in the figure 4-1 configuration, deleting all baseband and RF hardware; verify by test that the small signal performance of 3.2.1.1 is satisfied for all combinations listed in table IV-2. Each combination shall be tested at a doppler bandwidth of 10 Hz. In addition, two of the dual diversity tests of table IV-2 will be chosen prior to start of test by a Government representative and conducted at 0.1 Hz. All quad diversity tests shall verify BER over a range from 3×10^{-2} to 3×10^{-8} inclusive and all dual diversity tests shall verify BER over a range from 3E-2 to 3E-5 inclusive. Measurement times of BER shall be sufficient to provide 68% confidence that a measured BER is within plus or minus the true error rate. When tested with the RF hardware, the output power of the HPA shall be backed off from saturation by no more than 2 dB.

Table IV-2.

SMALL SIGNAL PERFORMANCE TEST

TOTAL CONFIGURED MBS RATE (Mbps)	MBS-I DATA RATE (Mbps)	MBS-II DATA RATE (Mbps)	SCBS DATA RATE (Kbps)	DIVERSITY	PROFILE	PERFORMANCE LEVEL
1.544	1.544	N/S	192	D, Q	$P_1 \rightarrow P_4$	I
3.088	1.544	1.544	192	D, Q	$P_1 \rightarrow P_4$	I
3.232	3.232	N/S	192	D, Q	$P_1 \rightarrow P_4$	I
6.464	3.232	3.232	192	D, Q	$P_1 \rightarrow P_4$	I
6.464	3.232	3.232	N/S	Q	P_4	I
6.464	3.232	N/S	N/S	Q	P_4	I
6.464	N/S	3.232	N/S	Q	P_4	I
6.464	3.232	N/S	192	Q	P_4	I
6.464	N/S	3.232	192	Q	P_4	I
6.464	N/S	N/S	192	Q	P_4	I
6.464	6.464	N/S	192	D, Q	$P_1 \rightarrow P_4$	I
9.696	9.696	N/S	192	D, Q	$P_1 \rightarrow P_4$	I, II
9.696	N/S	N/S	192	Q	P_4	II
*9.696	9.696	N/S	N/S	Q	P_4	I, II

N/S – NO SIGNAL
D – DUAL DIVERSITY
Q – QUAD DIVERSITY

*THIS TEST TO BE CONDUCTED BOTH IN THE FULL FIGURE 4-1 TEST CONFIGURATION AND THE REDUCED CONFIGURATION OF 4.2.3.7.1.

4.2.3.7.2 Production Sample Test. One production model shall be tested as in paragraph 4.2.3.7.1 except that only half the number of quad diversity tests shall be conducted. The particular tests to be conducted shall be chosen prior to the tests by a Government representative.

4.2.3.7.3 Abbreviated Operational Test. This test shall be an abbreviated small signal performance test. It shall be performed using a contractor-furnished tropo simulator and profile P5, quad diversity, 10 Hz Doppler, 9.696 Mbps data rate, performance level II. The BER shall be measured over a range from $3x10^{-2}$ to $3x10^{-6}$ inclusive. Measurement times of BER shall be sufficient to provide 68% confidence that a measured BER is within plus or minus the true error rate. This test shall be performed on the production models and the refurbished models to verify their compliance with this specification. It shall also be used in environmental qualification tests and reliability demonstration.

4.2.3.7.4 RF Spectrum Occupancy. In the figure 4-1 configuration and for each data rate and Performance Level, the modem shall be configured so as to satisfy the spectrum occupancy requirement for the corresponding authorized bandwidth given in table III-1. The satisfaction of the spectral mask in 3.1.2.2.3 shall be verified by the display of the spectrum analyzer. The output power of the HPA shall be backed off from saturation by no more than 2dB.

4.2.3.7.5 Aircraft in the Common Volume. In the configuration of 4.2.3.7.1 with Profile P4, 9.696 Mb/s MBS data rate, 10 Hz doppler bandwidth, performance level II, use the simulator in the Aircraft Mode. The attenuator/aircraft parameters shall be:

a. Power level of aircraft effect: 20dB greater than the highest level tap of P4

b. Initial delay of aircraft effect: 0.2 μsec

c. Maximum aircraft doppler bandwidth: 150 Hz

d. Duration of aircraft effect: 10 sec

e. Repetition of aircraft effect: every second period

Monitor the BER and FSI to verify that the requirements of 3.2.1.1.2 are satisfied during those periods of the simulated aircraft effect.

4.2.3.8 Synchronization Acquisition Time. The configuration of 4.2.3.7.1 shall be used with a single MBS at 9.696 Mb/s, authorized bandwidth of 7 MHz, and the simulator in the non-fading mode. An

oscilloscope shall be used to monitor the status of the internal time division multiplexer. The Tap Attenuator Switches on the Troposcatter Simulator may be used to turn the RF signal on and off. The oscilloscope trace shall be triggered by the step function in the RF envelope. The Frame Search Inhibit signal shall be monitored to determine the time it takes for this inhibit signal to become inactive once the RF input is applied to the modem interface. Verify that for a mean Eb/No corresponding to a BER of 10^{-2} the modem acquires synchronization in less than 500 milliseconds, and that for a mean Eb/No corresponding to a BER of 10^{-7} the modem acquires synchronization in less than one millisecond. By turning off one tap of the simulator and simultaneously turning on a tap that is approximately ± 2 bits displaced in time, verify that loss of frame synchronization is detected and reacquisition together occur in less than 50 msec.

4.2.3.9 Maintenance of BCI. With the configuration of 4.2.3.7.1 and an MBS of 9.696 Mb/s, a fading signal with Profile P4, doppler bandwidth of 10 Hz, authorized bandwidth of 7 MHz, quad diversity, adjust the mean Eb/No to the value corresponding to a BER of 3×10^{-8} as given by table III-2. Reduce mean Eb/No by 25 dB and verify no loss of synchronization for a full minute.

The configuration of 4.2.3.7.1 with single channel MBS data rate of 9.696 Mb/s shall be used with the troposcatter simulator in the nonfading mode, with a BER of 10^{-2}. Disconnect the counter of the test set and reconnect it to the frame search inhibit output. Configure the counter such that it increments once every time an Inhibit Signal occurs. This configuration will now indicate the total number of modem losses of synchronization and/or the times the modem signal-to-noise ratio drops below a critical value. As the signal-to-noise ratio is fixed, the counter will give a true indication of the number of losses of synchronization that occur over the test period. This test shall be conducted over a period in excess of 24 hours. A number other than zero on the counter indicates that one or more losses of synchronization occurred during the period and the test has therefore failed.

Verify by analysis the requirement that the internal demultiplexer maintains the existing synchronization while reestablishing synchronization.

4.2.3.10 Station Clock. With the back-to-back configuration of 4.2.3.3a, adjust the Station Clock 1 output +3 dB and -3 dB from nominal and verify error free operation under both conditions.

4.2.3.11 Dynamic Range. Verify by test the requirement of 3.2.1.2.

4.2.3.12 BER Performance Floor. For the small signal performance tests identified in 4.2.3.7 except with 20 dB more signal-to-noise ratio for each test, show by analysis that the modem will not exhibit a BER floor above 1E-10.

4.2.3.13 Adjacent Channel Interference. Conformance with 3.2.1.4 shall be verified using the configuration of 4.2.3.7.1 with Profile P4, 10.5 MHz authorized bandwidth, 9.696 Mb/s, 10 Hz doppler bandwidth, quad diversity. The separation of the center frequency of the interfering signal from that of the desired signal shall be 21 MHz. Appropriate additional equipment shall be used. Verify that the small signal performance requirements corresponding to these conditions in 3.2.1.1 are satisfied.

4.2.3.14 Co-Channel Interference. Conformance with 3.2.1.5 shall be verified using the configuration of 4.2.3.7.1 with Profile P4, 9.696 Mb/s 150 Hz fade rate, quad diversity. The interfering signal shall be in the same format and data rate as the desired signal.

4.2.3.15 Lockup Protection. Connect a pulse generator source to a representative digital input and output of the modem. Verify no outage or failure when the circuit is subjected to a pulse having the required characteristics.

4.2.3.16 Interface Protection. Prior to any of the other tests in 4.2.3 and its subparagraphs, subject the modem interface circuits to the conditions referenced in 3.1.2.1.13.

4.2.3.17 Electromagnetic Interference Tests. The modem shall be tested for compliance with the requirements of 3.3.2 and 3.3.2.1, in accordance with MIL-STD-462.

4.2.4 Performance Monitoring and Alarms

By deliberately inducing simulated failures (e.g., removing a card) demonstrate local and remote alarms. Measure open and close contact impedances.

4.2.4.1 Data Timing Input/Output. By disconnection, cause loss of data and timing and demonstrate local and remote alarms.

4.2.4.2 Modem Frame Alarm. By removal of appropriate card, demonstrate out of frame indication.

4.2.4.3 Frame Error Threshold. Reduce input signal to level corresponding to 10^{-1} and verify alarm.

4.2.4.4 Power Supply Alarm. Verify the power indicator is lit with the power on and extinguished with the power off. Verify by test that a visible indicator lights when any DC output is in an undervoltage or overvoltage condition.

4.2.4.5 IF Output Power. Reduce output IF power prior to sensor and verify alarm.

4.2.4.6 Overtemperature Alarm. Locate the overtemperature sensor. Using a heat gun, raise the temperature of the sensor until the Fault Monitor Lamp lights and the audio alarm turns on.

4.2.4.7 IF Received Signal Levels. Vary the input IF signal levels and verify that front panel display and monitor outputs correspond correctly to IF input levels within specified bounds.

4.2.4.8 Frame Bit Error Rate. Vary the input signal levels and use the test set and counter to determine BER of a MBS. Verify agreement between this BER measurement and front panel display and value made available for remote sensing. Repeat for all values of BER exponent.

4.2.5 Input Power

Connect primary power to the modem from a variable voltage source. Verify, by test, compliance with the power requirements. Verify that the modem is in the back-to-back error-free condition during this test.

4.2.6 Power Supply Protection

All power distribution equipment within the modem are to be individually inspected and component specifications analyzed to verify compliance with requirements of 3.1.2.4.1.

4.2.7 Emission Parameters

In addition to the tests identified in 4.2.3.7 and 4.2.3.7.1, a data/bandwidth change demonstration is to be performed by a technician. This change may be accomplished by component exchange. Verify that the demonstration requires less than four (4) hours to complete.

4.2.8 Weight

The modem without external cables or assemblies shall be weighed and verified to be less than or equal to the specified weight.

4.2.9 Dimensions

The height, width and depth of the modem outside dimensions without external cables shall be measured and verified to be in compliance with the requirements.

4.2.10 Reliability Demonstration Test

A reliability demonstration test shall be conducted to verify compliance with the requirements of 3.2.3.1. The accept/reject criteria for test plan IVC of MIL-STD-781 shall apply. The upper test, series MTBF (θ_2) shall be 3,000 hours. The lower test, series MTBF (θ_1) shall be 1,500 hours. The combined environmental test conditions (electronic stress, vibration stress, and thermal stress) of MIL-STD-781, paragraph 50.1 for Fixed Ground Equipment shall apply. The series reliability shall be tested and the mission MTBF shall be verified by analysis.

4.2.11 Production Reliability Acceptance Test

A Production Reliability Acceptance Test (PRAT) shall be conducted to verify that the modem was not degraded as a result of changes in tooling, processes, work flow, design, parts quality, or other characteristics during production. The contractor shall conduct PRAT on each production modem. For the PRAT, a cycle shall be defined as the first twenty-four (24) hours of the test profile approved for the reliability demonstration test (4.2.10). Each modem which completes two (2) failure-free cycles shall be accepted. For each modem, the contractor shall be allowed two (2) attempts to satisfy his requirements.

In case of failure, paragraphs 5.1.9, 5.8, and 5.9 of MIL-STD-781 shall apply. All modem PRAT's shall cease pending contractor verification of the elimination of the cause of failure, subject to the approval of the procuring activity.

4.2.12 Relevant Failures

A relevant failure for the modem or any of its subordinate elements shall be defined as a malfunction, including independent and dependent failures, which degrade performance below specified limits. All equipment malfunctions shall be classified as relevant failures unless proven to the satisfaction of the procuring activity to be non-relevant. A relevant failure is one due to the following causes: design defects, manufacturing defects, workmanship defects, software errors, physical or functional deterioration (such as wear-out, fatigue or tolerance degradation, or indeterminate causes).

4.2.13 Non-Relevant Failures

A non-relevant failure for the modem or any of its subordinate elements shall be defined as a malfunction which is not properly chargeable because it resulted from factors external to the system and is not indicative of any inherent operating defect. Such malfunctions are not to be included in the determination of equipment Mean-Time-Between-Failure (MTBF) and Mean-Corrective-Maintenance-Time (Mct).

4.2.14 Maintainability Demonstration Test

The Mean and Maximum Corrective Maintenance Time, as required in 3.2.4, shall be demonstrated in accordance with MIL-STD-471, Test Method 9. Compliance with the maintenance requirements shall be verified by demonstrating fifty (50) simulated faults selected in accordance with appendix A of MIL-STD-471 for apportionment among various LRUs. The selection process shall be based upon the relative failure contribution of the individual piece part (parts with a higher failure rate will be selected more often). The failure mode (short, open, degraded, etc.) shall also be randomly selected, based on the probabilities of each mode of failure occurring. Also, the failure Mode and Effects Analysis results shall be randomly selected, based on the probabilities of each mode of failure occurring. Also, the failure effect of the failure on the system. Fifty (50) simulated faults shall be randomly selected from a candidate list of two hundred (200) faults. Five faults shall be selected by a Government representative. The list of candidate faults shall be prepared prior to the maintainability test and shall be made available for test fault selection at the time of the test. Fault indicators designed into the system shall be included in the test.

4.2.15 Materials, Processes and Parts

Verification that all materials, processes and parts conform to requirements shall be by inspection of the parts, parts lists and applicable documentation. Parts derating will be verified by a Reliability Parts Stress analysis.

4.2.16 Identification and Marking

Verify by visual and mechanical inspection that all identification and markings on the modem are in accordance with MIL-STD-130.

4.2.17 Workmanship

Using MIL-STD-454 Requirement 9 as a guide, each modem is to be given a visual and mechanical inspection. Particular attention is to be given to the following:

a. Completeness

b. Identification markings and labels

c. Ease of operation of adjustable parts of movable parts, thumbscrews, controls and switches

d. Soldered and wire wrap joints

e. Fit of components in their respective positions and the manner of mounting

f. Grounding connections

g. Loose fastening and securing devices or parts

h. Wiring, cabling, and harnessing

i. Cleanliness of equipment

j. Ease of printed circuit card insertion and extraction

The satisfactory or unsatisfactory results of this inspection are to be indicated by checking the appropriate column on the Visual and Mechanical Inspection Check List.

4.2.18 Interchangeability

Conduct a performance test per 4.2.3.7 on any data rate or profile that is convenient. Interchange any 10 cards (or the maximum number of cards, if less) and repeat the test. The BERs for each point are to be within the specified value limits both before and after replacement of these cards.

4.2.19 Safety

Verify by visual inspection that all safety measures and warning markings are in accordance with MIL-STD-454 Requirement 1.

4.2.20 Human Engineering

Conformance to human engineering design principles established by MIL-STD-1472 is to be verified by systematic examination of the modem using an Equipment Adequacy check list. The check list covers the following categories for human factors assessment:

a. workspace design
b. general workspace hazards
c. panel layout
d. design of controls
e. design of visual and auditory displays
f. markings
g. design for maintainability

An evaluation of the operability of the modem is to be conducted as part of the performance of the tests.

SECTION 5

PREPARATION FOR DELIVERY

The equipment shall be prepared for delivery in accordance with the contract and MIL-STD-1188.